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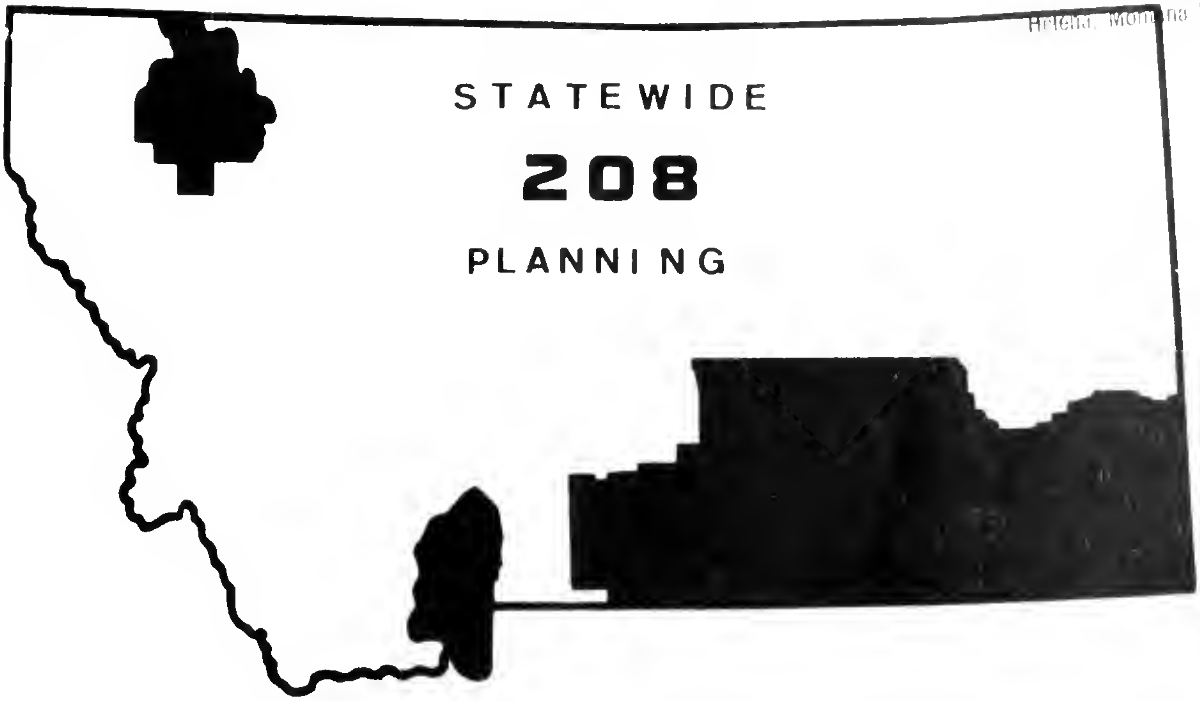

STATEWIDE

208

PLANNING

TO ACHIEVE AND PRESERVE

CLEAN WATERS

MINING NPS ASSESSMENT

Water Quality Bureau
Environmental Sciences Division
Department of Health and
Environmental Sciences

MINING AND MINERAL FUELS DEVELOPMENT IN THE MONTANA STATEWIDE 208 STUDY AREA: IMPLICATIONS TO WATER QUALITY

-FINAL DRAFT-

For

STATEWIDE 208 PROGRAM
WATER QUALITY BUREAU
ENVIRONMENTAL SCIENCES DIVISION
DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES
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Table of Contents

Appendices

Figures

Tables

<u>Tables</u>

INTRODUCTION

Mining of mineral commodities and mineral fuels has touched virtually every major drainage basin in western and central Montana. With the discovery of natural gas in the eastern portion of the Rockies, and an expanded potential development of bentonite and lignite in eastern Montana, mining has become of significance to the whole state. Not only is mining likely to affect all parts of the state, but the extent of mining developments is likely to increase in the future. As per capita mineral and energy consumption rates continue to rise, the economics of Montana mining will become more favorable and the extent of mining in the state will expand.

The objectives of this project are to assess the significance of existing mining related impacts to water quality, assess future mining developments in the state, assess the adequacy of existing statutes and their administration, and develop management strategies to correct old problems and avoid future problems.

This investigation evaluates the extent of past, present, and future mining development in the 42 county Statewide 208 Study Area of Montana. Thirty-six mineral commodities, as well as four mineral fuels, are evaluated as to their development potential. Specific and general water quality impacts associated with mining and mineral fuel developments are examined. Specific mining impacts are cited, based on a comprehensive interview program conducted throughout the Statewide 208 Area.

ACKNOWLEDGEMENTS

Background for portions of this report were prepared by Dean Culwell (coal development projections), Ambrey Gartner (mining and water quality), James Nybo (economic data on selected commodities), and Vicki Stiller (mineral commodities). Robert Rasmussen, Ambrey Gartner, and Connie Cole conducted numerous field interviews concerning specific mining problems.

The inventory of current mining problems was developed from a number of persons who provided information on mining and exploration activities and the nature of existing and potential water quality impacts. Of particular help was information obtained from individuals from the U.S. Forest Service, U.S. Bureau of Land Management, Montana Fish and Game Department, Montana Water Quality Bureau, Montana Department of State Lands, and the Montana Bureau of Mines and Geology. Several district rangers of the U.S. Forest Service were particularly helpful in identifying areas of specific concern. Bob Schumacher, Montana Fish and Game Department Area Fisheries Manager in Kalispell and Ron Marceaux, fisheries manager Bozeman, both provided helpful information in prioritizing mining problems in their respective area. Mr. George Krempasky, U.S. Bureau of Mines in Helena, supplied data on commodities and their importance in the state. Don Lawson of the Montana Bureau of Mines and Geology in Butte provided valuable insights into the current and past mining in Montana and its extent in prospects for development.

Typing and assembly of the manuscript could not have been completed without the patient and valuable assistance of Luanne Giler and Carol Clough.

CONCLUSIONS AND RECOMMENDATIONS

There are 64 hard rock operating permits, 927 small miners, 269 sand and gravel operations and 9 coal mining operations in Montana. The vast majority of these operations are in the 42-county Statewide 208 Study Area. A total of 131 mining-related water quality problems in streams were identified in the 208 Study Area. Most impacts are seasonal, but some are continuous, affecting an estimated 80 to 300 stream miles depending on criteria used to determine impact. Total estimated cost to correct these problems ranges from $5,000,000 to over $25,000,000 and even with this expenditure, only partial correction of problems would occur.

The majority of impacts are from inactive operations, particularly old placer and hard rock mines. Water quality problems are present at a small percent of all mining operations and many of these are from abandoned mines.

The most important strategy which the Water Quality Bureau could develop related to mining induced impacts is to recognize and properly manage future mining activities.

Following are specific conclusions and recommendations, listed in order of the supporting chapter and not in order of importance.

Conclusions

1. Of the 36 minerals occurring in commercially important quantities in the Statewide 208 Area, 25 have been mined in the past or are mined today. Twelve mineral commodities will experience the most significant levels of production in the next 10 to 20 years. These commodities are barite, bentonite, copper, gold, lead, phosphate, sand and gravel, silver, talc, tungsten, vermiculite, and zinc. Other commodities experiencing a smaller magnitude of development will be antimony, fluorspar, gemstones, graphite, limestone, and silica (Chapter VII).

2. Coal fields where there is a high to moderate development potential in the next ten years include the Bull Mountains (Musselshell); North Central field (Liberty, Hill, Blaine, Choteau); Wibaux, Little Beaver, and Four Buttes fields (Wibaux); fields in Dawson and Richland Counties; Redwater River area (McCone); and Weldon-Timber Creek field (McCone) (Chapter VIII).

3. Exploration and development for natural gas is continuing, particularly in northcentral and eastcentral Montana. The most important new factor in gas development concerns potentially vast reserves of the Overthrust Belt of the Rocky Mountains, extending from Glacier Park to Beaverhead County. Over 2 million acres of National Forest ground have been applied for oil and gas leasing. Development in much of the area would necessitate new road building. (Chapter VIII).

4. Crude oil production in Montana has declined from a high in 1968 and will probably not greatly expand from its current level of 33 million barrels annually (Chapter VIII).

5. No commercially minable uranium deposits are known to exist in the Statewide 208 Study Area. Prospecting is currently underway in ten counties in the area. Development potential in the next 10-15 years is low (Chapter VIII).

6. Acid mine drainage is the major and most important contributor of chemical stream pollution by mining activities in Montana. It is critical to anticipate future development of this problem (Chapter IX).

7. Waters of national recreation significance and prospective hard rock mineral development both occur in western Montana. New mining activities if allowed to discharge, will probably be required to meet the "Non-degradation"statement of the Montana Laws Regarding Water Pollution (Section

69-4808-2). Under present interpretation, the Montana Water Quality Standards could well be more stringent than BAT guidelines (Chapter IX,XII). BPCT guidelines have not yet been promulgated for the ore mining category, which includes most hard rock mining and uranium mining (Chapter XII).

8. Accidents are an inevitable part of any complex operation including mining operations. All events . have a probability of occurrence. The likelihood that accidents will occur in the future at mines is assured. In planning of future mines in Montana, accidents and their treatment must become part of new mine planning efforts. Accidents with a reasonable probability of occurrence, or accidents with a low probability of occurrence, but which might have significant water quality impacts, must be considered. Adequate treatment facilities must be available to treat accidents (Chapter IX).

9. Fifty-seven problem sites or mine drainages of unknown quality were identified; nineteen problems or suspected problems associated with sand and gravel mining were identified, and forty-four streams or basins adversely affected by placer mining were noted. Major impacts are present in Sanders and Mineral Counties in the lower (76N) and middle Clark Fork drainages; in Granite, Powell, Deer Lodge, and Silver Bow Counties in the upper Clark Fork (76G) drainages; the Beaverhead River drainage; in Cascade and Judith Basin Counties in the middle Missouri River drainage; and in Phillips County in the middle Missouri River and People's Creek drainages.

Impacts from sand and gravel mining are found throughout the state, from Richland County to Lincoln County. Major streams impacted include the Bitterroot, Clark Fork, Teton, and Sun Rivers. Gold placer mining has had its greatest impact in Beaverhead, Madison, Lewis and Clark, Powell, Broadwater, Missoula, and Mineral Counties. Nearly every county which

experienced placer mining in the past still experiences some impact from these activities.

The 131 identified specific problems can be grouped into several type categories:

Problem Type	Percent
Mine drainage	17
Tailings and waste dump erosion	34
Placer workings	35
Sand and gravel mining	12
Roads and ground disturbance	2

(Chapter X)

10. Erosion and subsequent sedimentation in streams are the most common impacts of mining to water quality in the state. The greatest number of identified problems in this investigation relate to erosion from old placer mining operations and erosion of waste dumps and tailings piles. Acid mine drainage and erosion of tailings constitute the most significant sources of chemical stream pollution by mining activities in the state. Non-acid mine discharges have not been identified as a major problem (Chapter X).

11. Order of magnitude estimates of the cost of correcting mine-related problems identified in this study range from 5.6 million to 25 million and even at this cost, problems would only be partially corrected. Additional surveys of mining impacts might increase this estimate (Chapter X).

12. The extent of present and past mining and the potential for future development combine to make the upper Clark Fork, Beaverhead River, and the upper Missouri River drainages the drainages most affected by mining in the Statewide 208 Area (Chapter X).

13. It has been shown that sand and gravel operations in a number of areas significantly affect water quality. Although sand and gravel mining has not received the widespread attention that activities such as coal strip mining have received, the importance of sand and gravel mining to water quality is signficant. The Water Quality Bureau should carefully monitor sand and gravel mining in and near streams and continue the cooperative working relationship with the Open Cut Bureau of the State Lands Department (Chapter X).

14. Coal strip mining is a well regulated industry, particularly regarding impacts to water quality. There are clear requirements for hydrologic monitoring of mining impacts, maintenance of sediment control facilities, and protection of hydrologic systems, particularly alluvial valley floors. Under these regulations and with the present emphasis on enforcement of state and federal statutes, water quality problems associated with this mining will not be a major problem (Chapters XI, XII).

15. There are two MPDES discharge permits for mining operations in the Statewide 208 Area and one more application for discharge is pending (Chapter XI).

16. Few water quality problems with oil and gas development have been identified. This may not accurately reflect the extent of problems since both the Montana Oil and Gas Commission and the U.S. Geological Survey, Conservation Division, are understaffed and are not able to closely monitor oil and gas operations. Road building and other associated work may seriously impact water quality in the Rocky Mountains (Chapter XI).

17. The major potential aspects of water quality problems in uranium mining relate to problems of tailings disposal·of processed material and disposal of toxic liquids in aquifers. There are also some problems related to success of reclamation of mined lands for uranium. Several toxic substances are used in uranium operations and control of these waters is important in maintenance of water quality (Chapter XI).

18. The Montana Oil and Gas Commission and USGS, Conservation Division, have responsibilities for enforcing state and federal oil and gas regulations. These agencies have little contact with the Water Quality Bureau. Many aspects of the oil and gas regulations are not mandatory and carry weak penalty clauses (Chapter XII).

19. Many specific water quality problems result from small miner activities. Presently, the Hard Rock Bureau works with small miners in eliminating or abating water pollution problems . Due to confidentiality problems, enforcement of water pollution sections of the Hard Rock Act is inadequate. The Department of State Lands makes no determinations of water pollution because it does not have the expertise to make such decisions and the Department cannot release confidential information to the Water Quality Bureau about potential water pollution problems. There are presently over 900 small miner exclusion statements on file with the Department of State Lands. In the administration of the Hard Rock Act, no violation has ever been issued to any small miner for violation of water quality provisions of the Act (Chapter XII).

20. The United States Mining Law of 1872 permits development of all locatable minerals on all federal lands not specifically excluded from mining. The federal land managing agency can require mitigating measures to protect surface resources but cannot deny mining activities (Chapter XII).

21. There are no promulgated state groundwater standards (Chapter XII).

22. The Hard Rock Act has the least amount of regulatory authority in laws administered by the Department of State Lands. Permit denial provisions are vaguely worded, as are specific enforcement measures (Chapter XII).

Recommendations

1. Research on Scarce Metal Mining and Environmental Problems

A number of scarce metals are found in Montana including antimony, copper, lead, platinum, silver, tungsten, and zinc. Mining of a number of these commodities has the potential to cause significant water quality impacts due to mine drainage and erosion from poorly sited waste and tailings areas. The pressure to mine scarce minerals in Montana will increase in future years both because national needs are increasing, and because mineable deposits of these materials are found within the state. Comprehensive reviews should be conducted concerning water quality impacts associated with mining of these commodities. National needs for these scarce metals will be greatest, economics of mining these metals will be most favorable, and the inevitable political and economic pressures will be great to produce such materials. Thus, the Water Quality Bureau should be knowledgeable on environmental effects associated with mining of these materials (Chapter VIII, IX, Appendix A).

2. Cyanide Leaching

Cyanide leaching of low-grade ores and waste dumps are a likely expanding element of mining activity in Montana. Potential environmental impacts may be significant if such operations are not designed and operated properly. Past operations of cyanide leach operations in Montana have caused significant water quality problems. The Water Quality Bureau should examine each proposed and operating cyanide leach operation and monitor activities to ensure water quality standards are not violated and are not likely to be violated. A process to ensure that the Water Quality Bureau is notified of existing and proposed cyanide operations should be developed (Chapter VII, X).

3. Oil and Gas Regulation

The current enforcement of oil and gas regulations by federal and state agencies needs to be revised. There is not a good working relationship between federal and state agencies concerning oil and gas. Neither the Montana Oil and Gas Commission nor the U.S. Geological Survey, Conservation Division, is adequately staffed to properly regulate all oil and gas activities. Neither agency is aware of more than a handful of specific water quality impacts from oil and gas activities, despite the significant nature of oil and gas development in the state. The U.S. Geological Survey has cited some pollution problems, however, they are not coordinated with the Water Quality Bureau, and, in fact, seldom are in contact with the state. Similarly, the Oil and Gas Commission has little contact with the Water Quality Bureau. Because of the complexity and extensiveness of oil and gas activities, a comprehensive review of the legal framework and regulation of those activities, on both the federal and state level, is badly needed, particularly in view of imminent expansion of the industry into mountainous portions of western Montana (Chapter VIII, XI, XII).

4. Groundwater Pollution From Mining

Presently there are no state laws or rules specifically related to groundwater pollution; and mining activities that adversely affect groundwater, are not clearly regulated. Specific groundwater regulations are needed to control groundwater pollution (Chapter IX, XII).

5. Environmental Assessments of Mining Activities

Accidents and other unanticipated problems occur during mining operations. The Water Quality Bureau, and other regulatory agencies, should assess the accident potential so it can be controlled in mining operations.

Evaluation should be made of potential accidents, their over-the-mine life probability and potential environmental significance. This analysis will highlight the probable impacts of the mining operations (Chapter IX,X,XI).

6. Enforcement Provisions of Open Cut Act

Under present law, violations concerned with operating without a permit, under the Open Cut Act, are prosecuted by the County Attorney. In several cases, county attorneys have not prosecuted these violators. In order to assure consistant enforcement of the Open Cut Act, a review should be made of the relationship of country attorneys, the attorney general, and the Department of State Lands relative to enforcement of this Act (Chapter IX, XII).

7. Applicability of Hard Rock Act to Tailings Pond Review and Reclamation

The Hard Rock Act is unclear as to its applicability to reclamation and operation of tailings ponds and jurisdiction over tailings ponds is presently being contested. Tailings erosion is a significant mining related problem in the state. Regulation of tailings pond construction and insurance that tailings ponds will not become long-term water quality problems, is important to minimize mining related water quality impacts. The Hard Rock Act should be amended to specifically include tailings ponds (Chapter IX.X,XII). or clarify their relationship to processing facilities.

8. Revision of Hard Rock and Open Cut Acts

Under these Acts, neither hard rock nor open cut mines are presently required to monitor surrounding ground and surface waters prior to, or during mining operations, or during reclamation. Monitoring of surface and groundwater conditions permits detection of changes in water quality. Problems can thus be anticipated and more adequately handled. Both the Open Cut and Hard Rock Acts should be amended to require that data be submitted

to assure no adverse damage from mining to surrounding hydrologic systems. Hydrologic monitoring of coal mining is comprehensive and some aspects of this monitoring strategy could be of significant value in hard rock and open cut.

Particularly noteworthy in existing federal strip mine regulations is the requirement that all runoff from reclaimed and disturbed areas must pass through settling ponds. This requirement ensures that additional increases to the sediment load of surrounding streams from accelerated erosion at mining operations will be controlled. Similar requirements for open cut and hard rock mining would control a significant source of non-point pollution to streams. Particularly in areas of high annual precipitation, the potential of erosion from unstable areas is great. It is important that all reclamation areas associated with any type of mining be monitored so that it is clear when and if erosion rates on reclaimed ground are approaching normal conditions.

Provision wherein a regulatory agency can prohibit mining in areas of special value, or where unforeseen adverse impacts may occur, are not provided in either the Open Cut or Hard Rock Mining Acts. Specific denial provisions are included under Section 9 of the Montana Strip and Underground Mine Reclamation Act, which regulates coal and uranium mining. Under existing federal and state statutes, locatable minerals can be developed anywhere that mining is not specifically prohibited. With selective denial provisions in all mining laws, the Montana Reclamation Division would be able to prohibit mining activities where water quality problems cannot be mitigated. A statutory selective denial provision would have sounder legal standing than MAC 26-2.10(6)-S10140(3) of the Open Cut Act, which prohibits mining in stream beds. This rule represents a sound policy

regarding protection of streams and needs to be strengthened. No similar rule exists under the Hard Rock Act. Particularly with sand and gravel mining, the prohibition of mining in stream beds is justified; sand and gravel deposits are abundant in Montana with adequate reserves outside channel and floodplain areas (Chapters IX,X,XII, Appendix A).

9. Confidentiality Provisions of Hard Rock Act

Reinterpretation or amendment of Section 21 (50-1221) of the Hard Rock Mining Act is needed to permit access by the Water Quality Bureau to presently confidential information concerning the activities of small miners and exploration efforts. Small miners are known to cause water quality problems in Montana. No water quality violation to any small miner activity has ever been issued by the Montana Reclamation Division. The Department will not make determinations of water pollution and cannot release information on suspected water pollution problems to the Water Quality Bureau. Confidentiality is a hindrance to enforcement of water quality laws and regulations.

Little information is available concerning the effect of exploration activities on water quality. However, by their very nature, exploration activity can cause water quality problems. The Water Quality Bureau should be appraised of the location of exploration activities, particularly near streams so that the Bureau can work with developers to meet water quality standards.

The goal of the Water Quality Bureau's efforts should be in preventing development of future problems. Hopefully, over time, existing and past problems will be corrected. The Water Quality Bureau cannot hope to work with small miners in the state, if the Bureau does not know who they are and where they are working. It is difficult to formulate water quality management

plans for specific streams if the location and extent of exploration activity is unknown (Chapters X,XII).

10. U.S. Forest Service and Water Quality Bureau Communication

As part of this investigation, discussions were held with the U.S. Forest Service District Rangers. It has become clear that better communications need to be developed between District Rangers and Water Quality Bureau personnel. U.S. Forest Service personnel have good information regarding mining related water quality problems in their respective districts. A number of Forest Service District Rangers are unaware that the Water Quality Bureau is the lead state agency on water quality matters and do not routinely refer water quality problems to the Bureau. In some cases, mining related problems discovered by the Forest Service are handled by the Forest Service staff without coordination with the Water Quality Bureau or the Department of State Lands. Frequently, the Department of State Lands is notified by the Forest Service of mining problems without notification of the Water Quality Bureau. The Water Quality Bureau should seek to make regular contact with District Rangers (Chapters X,XII).

11. Investigation of Specific Problem Sites

Problems cited in this report are primarily based on information from knowledgeable persons and from available reports. Limited examinations of selected field problems were conducted. Most water quality problems identified in this report need to be more thoroughly examined in the field.

This report probably does not identify all mining impacts to water quality in the state. Additional detailed field investigations are needed to identify further problems. It is clear from information reviewed that detailed field studies have never been made to identify every mining-related water quality impact. Pederson (1977) investigated a portion of the northern

Boulder batholith and found a number of discharging adits and other unreported impacts to streams in this area. Additional detailed investigations are needed in other mining areas where there has been extensive mining; current small miner activity, or where future widespread development is likely. In particular, areas of known pyrite association with metalliferous ores should be studied for possible acid mine drainage problems.

Suggested areas for further investigation include portions of the Boulder batholith, mining districts of the upper Clark Fork drainage basin, mining districts of Beaverhead, Madison and Mineral Counties; the Garnet Range, and mining districts in the Little Belt and Castle Mountains of central Montana.

These studies should include examination of mining sites, plotting of locations of abandoned and existing workings, identification and sampling of mine discharges, and assessment of specific corrective techniques and costs. Priority basins for investigation are identified in Appendix D. Major problems (Table 12) should receive maximum attention (Chapter X; Appendix A,D).

12. Small Miner Education and Coordination Program

Activities of small miners are identified as having a significant impact on water quality. All miners may not be receiving adequate council on potential impacts of their operations on water quality. The Water Quality Bureau should develop an education program where small miners in the state are appraised on how they might avoid water quality impacts to streams and where the Water Quality Bureau can offer specific assistance to small miners on how to better plan and conduct their mining operations.

The Water Quality Bureau should develop a liason with local mining associations, such as the Southwest Mining Association. These associations offer an opportunity to contact a number of small miners at one time. A regular informational program could be established by the Water Quality Bureau for presentation to miner groups (Chapter X).

13. Correction of Old Mining Problems

Funding is needed to correct old mining problems. Such old problems are costly to correct. Several hundred thousand dollars spent at one mine may not significantly improve the water quality of a stream, especially if other mining activity has occurred in the basin. Several difficulties arise in making the current or past owners responsible for existing mine problems. In many cases, current mine owners do not have the financial resources available to solve the most significant mine related water quality problems at their mines. This is especially the case where a small miner is prospecting an old mine site which formerly produced significant amounts of waste and tailings materials. A special fund developed by apportioning a small percentage of existing mining tax revenues, or an additional tax on mining operations in the state, could be used to correct the most significant mine problems (Chapter X).

14. Waste Dump and Tailings Pond Siting

Erosion of waste dumps and tailings dumps have been identified as important mining related impacts to water quality in the state. In future siting of waste dumps and tailings dumps, long-term land stability, erosion trends, and stream channel geomorphology should be considered. Waste dumps and tailings piles sited near stream channels may be subject to future erosion during periods of stream channel change (Chapter X).

15. Correction of Old Problems by New Operators

Many existing mining properties have pollution problems that range from minor to very significant. There is a legal question of responsibility for old problems. The legal responsibility of current or past owners and new operators for existing mining problems, should be determined. This is an important factor for mining firms aquiring old properties and for the Water Quality Bureau in correction of old pollution problems (Chapter X,XII).

16. Coal Strip Mining - Hydrological Impacts

Additional research is needed concerning the ability of aquifers to be re-established at mines particularly regarding re-establishment of alluvial aquifers. Final Interim Regulations require perched aquifers to be re-established as essentially a mirror image of the pre-mining groundwater situation. If these regulations are to be enforced to their fullest extent, additional research needs to be completed guiding the coal industry in best management practices regarding aquifer re-establishment (Chapters XI,XII).

17. Reclamation Division Staffing

Staffing priorities of the Reclamation Division are heavily weighed towards regulation of coal strip mining. There are significant impacts to water quality from hard rock mining and sand and gravel mining. Because of man-power limitations, emphasis in hard rock and open cut regulation focuses on cursory inspection of literally hundreds of operations. Little time is available for detailed investigation of more than just a few specific problems.

Staffing of the Hard Rock and Open Cut Bureaus should be expanded to include professional water quality specialists and reclamation planners whose primary responsibility is review and investigation of specific mining and reclamation problems. If staffing of the Hard Rock and Open Cut Bureausis not increased, the Reclamation Division should consider redefining roles of current staff. Responsibilities could be divided between individuals responsible for professional review of mining problems related to water quality, soils, revegetation, and wildlife, and other staff responsible for inspections of mining properties. In this way, problems related to all mining could be prioritized regardless of Bureau jurisdiction.

Similarly, activities of the Administrator of the Reclamation Division should be more evenly divided amongst concerns of each Bureau. Discussions with the present, and former, Administrators indicate that due to rapidly expanding coal activities and limited staff, they are not aware of details of many reclamation problems associated with hard rock and open cut mining (Chapter XII).

18. Needed Revisons of United States Mining Law 1872

Under this law, mining of locatable minerals must be accomodated on all federal lands open to mining. No specific denial criteria exists under this Act. This report shows that increased exploration and development pressure will be exerted in Montana throughout the federal domain regulated by the 1872 Law. Revisions of this law have been proposed in Congress. An administration supported bill would develop a leasing system for all minerals developed on federal lands. Discussions conducted during this investigation with several memebers of the U.S. Forest Service, indicate that there is presently inadequate control over mining activities on Forest Service Lands.

Although this investigation is not comprehensive enough to specifically suggest revisions of the 1872 Mining Law, it is clear that this law inadequately protects water quality. The Water Quality Bureau should be involved in a state-federal assessment of the 1872 Mining Law to ensure that any ammendments in this law are applicable to Montana problems (Chapter XII).

19. <u>Operating Mines Without Discharge Permits</u>

Some operating mines without discharge permits have impacted state waters. The Water Quality Bureau does not regularly inspect mines not having discharge permits. The Water Quality Bureau should initiate a program of inspecting all major operating mines in Montana to review adequacy of pollution control efforts. Closer liason between the Water Quality Bureau, U.S. Bureau of Mines, Montana Bureau of Mines and Geology, and Department of State Lands is needed. These agencies are particularly knowledgeable concerning the extent of mining activity in the state and possibilities of future development of commodities. These agencies are also knowledgeable about similar activities in other states. Regular contact between the Water Quality Bureau and these agencies would assist in determining extent of mining operations in the state and nature of water quality management at similar mines in other states (Chapter XII).

20. <u>Highway Department Liason with State Lands Department</u>

The Highway Department has not notified or gained approval from the Department of State Lands for all its sand and gravel excavations, despite an agreement to this effect between the two agencies. A few of these unapproved excavations have taken place in or near streams.

Unapproved excavations are causing reclamation problems. Consistant with efforts to eliminate mining in or near stream areas and consistant with the purpose of the Open Cut Act to ensure sound reclamation of mined lands, the coordination of Highway Department-mining related activities needs to be improved (Chapter XII).

21. Development of Best Management Practices from Mining Industry

Given the likelihood of future expansion of mining activities in Montana, the Environmental Protection Agency best management practices will be important in water quality management. Currently, BMP's exist only for coal, phosphate, and sand and gravel mining. Guidelines for other mining BMP's are needed so the Water Quality Bureau can develop discharge requirements. Best management practices for mining roads need to be promulgated. Mining roads may be an important non-point pollution source related to sedimentation in streams. Particularly with the expansion of oil and gas development and new road construction into the Rocky Mountains, specific guidelines, reviewed by the Water Quality Bureau, should be promulgated (Chapter XII).

MINERALS AND MINERAL FUELS IN MONTANA

Physiographically and geologically, Montana can be divided into the northern Rocky Mountains and the northern Great Plains. Each area has a distinct topography, bedrock geology, and mineral resource base. The Statewide 208 Study Area includes both regions.

Western Montana, the heart of the northern Rockies, is characterized by deeply dissected mountain uplands, and in southwestern Montana, large intermountain valleys. Intrusive granitic rocks such as the Idaho batholith, Boulder batholith, and Tobacco Root batholith are prevalent, and metalliferous ore deposits are, in most cases, closely associated with these intrusions. Metals found in these deposits include gold, silver, copper, lead, and zinc. Historically, these type deposits have generated the most significant mining development in the state.

In northwestern Montana, stratabound copper deposits are found in the Precambrian Belt Series rocks, a thick sequence of very old sedimentary strata. In southwestern Montana, deposits of talc, iron ore, graphite, sillimanite, and kyanite are found in Precambrian Cherry Creek group. Limestone is found in the Mississippian Mission Canyon Formation and phosphate in the Mesozoic Phosphoria Formation. Both formations are widespread.

The eastern border of the Rocky Mountains is marked by a 10-to-30-mile-wide strip, known as the Overthrust Belt, that is distinguished by severe rock deformation. This area, extending from Glacier National Park, through Beaverhead County, and south to Utah, may be a source of vast natural gas supplies.

Central Montana is characterized by isolated mountain ranges, rising out of the surrounding plains. The ranges formed as a result of block faulting, igneous intrusion, or volcanism. Metalliferous ores have been mined in the Little Rocky Mountains, North Moccasin Mountains, Judith Mountains, and Little Belt Mountains. The intervening plains of this region are characterized by broad structural anticlines, which have trapped oil and natural gas supplies. Such structures as the Cat Creek anticline, the Kevin-Sunburst dome, and the Sweet Grass arch have been highly productive.

Eastern Montana is underlain almost entirely by flat-lying Mesozoic and Cenozoic strata, and the topography is typical of the Great Plains. No metalliferous ores are found in this region, but large reserves of bentonite are found near Malta, Glasgow, and north of Forsyth. Abundant lignite reserves underlie the central and northern parts of this area, and oil is produced from Williston Basin counties such as Richland, Dawson, and Roosevelt.

There are 200 mining districts in the state (Figure 1), concentrated in western and central Montana. Many of these districts experience little or no mining today, but as exploration methods become more sophisticated and economic conditions change, districts may come back into production.

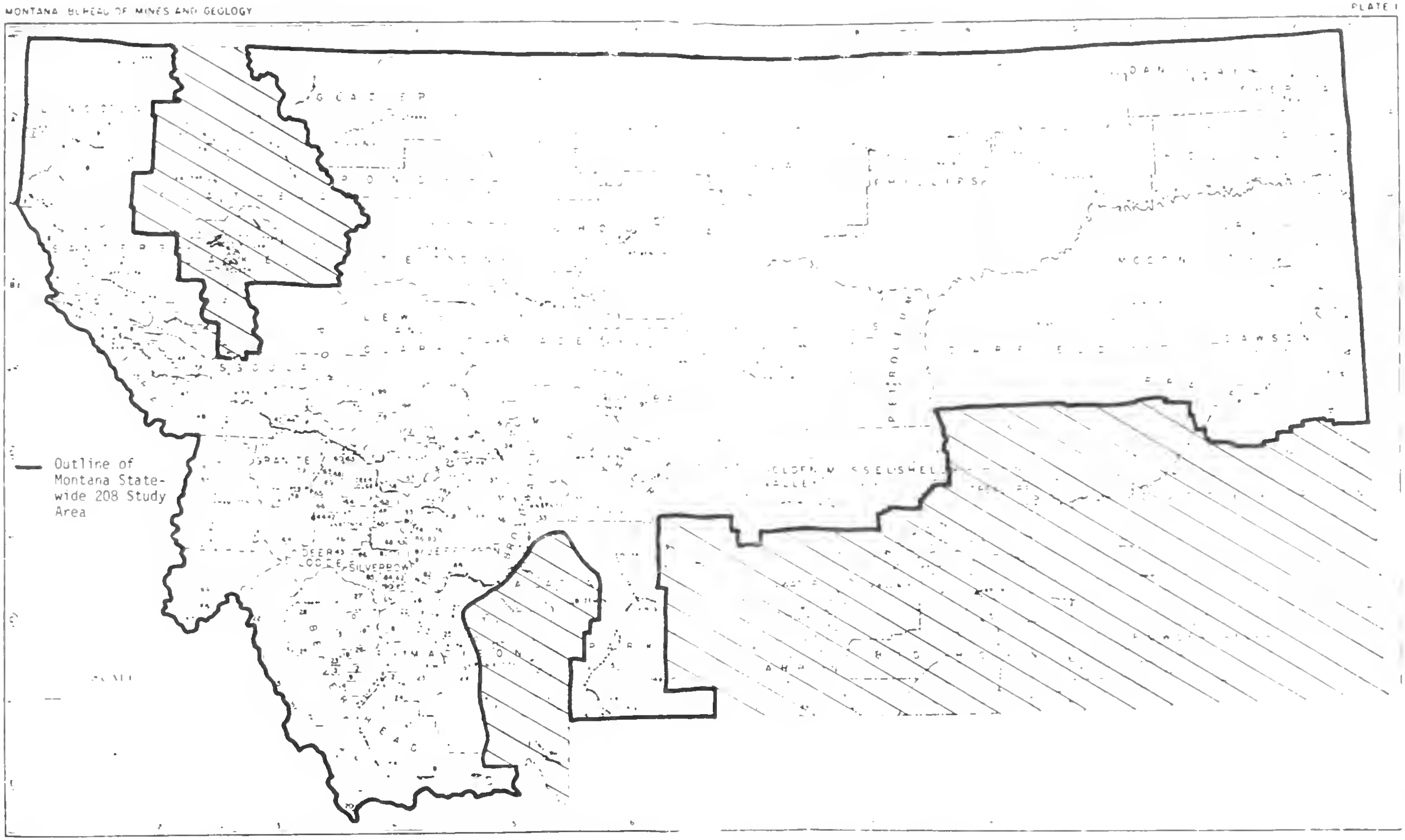

FIGURE 1: MAP SHOWING DISTRIBUTION OF MINING DISTRICTS AND STRIPPABLE COAL FIELDS IN MONTANA

(Krohn and Weist, 1977)

LIST OF MINING DISTRICTS

MINING DISTRICTS

Beaverhead County, D-4

1. Ajax
2. Argenta
   (Montana)
3. Bald Mountain
4. Bannack
5. Beaverhead
   (Dark Horse)
   (Mulchy Creek)
6. Big Muddy
7. Blacktail
8. Bloody Dick
   (Beaverhead)
9. Blue Wing
10. Bryant
   (Hecla)
   (Glendale)
11. Chinatown
   (Armstead)
12. Dillon
   (Carter Creek)
   (Frying Pan Basin)
13. Elkhorn
   (Coolidge)
   (Wise River)
14. Horse Prairie
15. Jake Creek
16. Lost Creek
   (Brown's Lake)
   (Rock Creek)
17. Medicine Lodge
18. Monida
19. Mount Torrey
20. Niccolia
21. Nogo
   (Apex)
22. Pioneer
23. Polaris
   (Lost Cloud)
24. Ruby
25. Saginaw
   (Jackson)
26. Utopia
   (Birch Creek)
27. Vipond
28. Wisdom
   (Big Hole)

Blaine County, A-6

29. Bearpaw

Broadwater County, C-5

30. Confederate Gulch
   (Backer)
   (Canton)
   (Diamond City)
31. Deep Creek
32. Hellgate
33. Lone Mountain
34. Magpie Gulch
35. Park
   (Hassel)
   (Indian Creek)
   (Townsend)
36. Radersburg
   (Cedar Plains)
37. Winston
   (Beaver Creek)

Carbon County, D-7

38. Clark Fork
39. Hellroaring
40. Silver Run

Cascade County, B-5

41. Neihart
   (Montana)

Deer Lodge County, D-3

42. Blue Eyed Nellie
   (Silver Lake)
43. French Gulch
44. Georgetown
   (Southern Cross)
   (Cable)
45. Girard
46. Heber
   (Mill Creek)
47. Lost Creek
   (Dry Gulch)
   (Antelope Creek)
48. Oro Fino
   (Dry Cottonwood)

Fergus County, B-7

49. Cone Butte
50. North Moccasin
   (Kendall)
51. Warm Springs
   (Gilt Edge)
   (Maiden)

Flathead County, A-3

52. Hog Heaven
   (Flathead)
   (Kila)
53. Star Meadow
   (Lupfer)
54. Whitefish

Gallatin County, D-5

55. Eldridge
56. West Gallatin
   (Spring Hill)

Granite County, C-3

57. Alps
   (Bonita)
58. Antelope Creek
59. Combination
   (Henderson)
   (Black Pine)
60. Dunkleburg
61. Frog Pond Basin
62. Garnet
   (Top-o'Deep)
   (First Chance)
63. Maxville
   (Wyman)
   (Gird Creek)
64. Moose Lake
65. Philipsburg
   (Flint Creek)
   (Granite)
66. Red Lion
   (Cable Mountain)
67. Rock Creek
68. Rose Mountain
   (Gold Creek)
69. South Boulder
   (Princeton)
70. Welcome Creek

Jefferson County, C-4

71. Alhambra
   (Hot Springs)
   (Golconda)
72. Amazon
73. Basin
   (Cataract)
   (Comet)
74. Beaver Gulch
75. Boulder
76. Big Foot
   (State Creek)
77. Clancy
   (Lump Gulch)
   (Buffalo Creek)
78. Colorado
   (Corbin)
   (Gregory)
   (Wickes)
79. Elkhorn
80. Elk Park
81. Homestake
82. Little Pipestone
83. Lowland
84. McClellan
   (Mitchell Creek)
85. Montana City
86. Nez Perce
87. Pipestone
88. Whitehall
   (Cardwell)
89. Whitetail

Judith Basin County, B-6

90. Barker
   (Hughesville)
91. Running Wolf
92. Yogo

Lake County, B-2

93. Elmo
   (Chief Cliff)

Lewis and Clark County, B-4

94. Austin
   (Greenhorn)
95. Blue Cloud
96. Gould-Stemple
   (Fool Hen)
   (Poorman)
97. Heddleston
   (Blackfoot)
   (Silver)
98. Helena
   (Last Chance)
   (Springhill)
   (Unionville)
   (Owyhee)
99. Lincoln
   (McClellan Gulch)
   (Seven-up Pete Gulch)
   (Keep Cool Creek)
   (Liverpool Creek)
   (Stonewall Mountain)
100. Marysville
   (Bald Butte)
   (Ottawa)
101. Missouri River
102. Ophir
103. Rimini
   (Vaughn)
   (Bear Gulch)
104. Scratchgravel Hills
   (Grass Valley)
105. Wolf Creek
   (Gladstone)
106. York

Lincoln County, A-1

107. Cabinet
   (Fish River)
108. Libby
   (Snowshoe)
109. Rainy Creek
110. Sylvanite
111. Tobacco River
112. Troy
   (Grouse Mountain)
   (Callahan)
113. Wolf Creek

Madison County, D-5

114. Bismark
   (Wilmah)
115. Cherry Creek
116. McCarthy Mountain
117. Norris
   (Lower Hot Springs)
   (Upper Hot Springs)
118. Norwegian Creek
119. Pony
   (Mineral Hill)
120. Potosi
121. Renova
   (Bone Basin)
   (Mayflower)
122. Rochester
   (Rabbit)
123. Ruby Mountains
124. Sand Creek
125. Sheridan
   (Mill Creek)
   (Brandon)
   (Indian Creek)
   (Pamsborn)
126. Silver Star
   (Iron Rod)
127. South Boulder
   (Mammoth)
128. Tidal Wave
   (Twin Bridges)
129. Virginia City
   (Summit)
   (Pine Grove)
   (Highland)
   (Fairweather)
   (Nevada)
   (Junction)
   (Alder Gulch)
   (Brown's Gulch)
   (Granite Creek)
   (William's Gulch)
   (Barton Gulch)
130. Washington
   (Meadow Creek)
   (McAllister)

Meagher County, C-6

131. Beaver
   (Elk Creek)
   (Thompson Creek)
132. Castle Mountains
133. Murray
   (Battle Creek)
134. Musselshell
   (Copperopolis)

Mineral County, B-2

135. Cedar Creek
   (Quartz Creek)
   (Trout Creek)
136. Denemora
   (Big Elk)
   (Saltese)
137. Iron Mountain
   (Superior)
138. Keystone
139. Packer Creek
140. Rock Island
141. St. Regis
   (Deer Creek)
   (Ward)

Missoula County, C-3

142. Clinton
   (Wallace)
143. Coloma
   (Potomac)
144. Copper Cliff
145. Elk Creek
146. Nine Mile Creek
   (Kennedy Creek)
147. Petty Creek
148. Woodman
   (Lolo)

Park County, D-6

149. Cowles
   (Haystack)
150. Crevasse
151. Emigrant
   (Chico)
152. Horseshoe
153. Jardine
   (Bear Gulch)
   (Sheepeater)
154. New World
   (Cooke City)
   (Blackmore)

Phillips County, A-9

155. Little Rockies
   (Landusky)
   (Zortman)

Powell County, C-4

156. Big Blackfoot
   (Helmville)
157. Elliston
   (Ontario)
   (Nigger Hill)
158. Emery
   (Zosell)
159. Finn
   (Washington)
   (Jefferson, and
   (Buffalo Gulches)
160. Garrison
161. Ophir
   (Snowshoe)
   (Deadwood)
162. Oro Fino
163. Pioneer
   (Gold Creek)
164. Racetrack
   (Danielsville)

Ravalli County, C-2

165. Curlew
166. Hughes Creek
   (Alta)
   (Overwich)
167. Mineral Point
168. Pleasant View
169. Slate Creek
170. Three Mile

Sanders County, B-1

171. Blue Creek
   (Heron)
172. Camas Prairie
   (Perma)
173. Plains
174. Prospect Creek
175. Revais Creek
   (Dixon)
176. Sleepy Creek
   (Belknap)
177. Silver Butte
   (Vermillion)
   (Cabinet)
178. Spring Gulch
179. Thompson River
180. Trout Creek
181. White Pine
   (Eagle)

Silver Bow County, D-4

182. Basin Creek
183. Butte
   (Summit Valley)
   (Lost Child)
184. Divide Creek
185. Fleecer Mountain
186. German Gulch
   (Siberia)
187. Highland
188. Independence
189. Melrose
   (Camp Creek)
   (Soap Gulch)
190. Moose Creek

Stillwater County, D-7

191. Nye
192. Stillwater
193 Yellowstone River

Sweet Grass County, D-6

194. Big Timber Canyon
195. Boulder River
196. Independence
197. Natural Bridge
198 West Stillwater

Toole County, A-5

199. Gold Butte
200. West Butte

(Krohn and Weist, 1977)

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WATER QUALITY IN MONTANA

The topographic and geologic diversity of the Statewide 208 Study Area results in regional variability in water quality. Water quality is generally good to excellent in most of western Montana, particularly in the mountainous areas. All western Montana waters are of a calcium-bicarbonate type. The central and northern portions of western Montana, underlain by sedimentary rocks, have excellent quality waters. This water typically has low total dissolved solids and low concentrations of nutrients and metals. In southwestern Montana, and in the mountainous areas of westcentral Montana, water quality is more variable and commonly contains more dissolved minerals than streams of northwestern Montana. These waters are good to excellent in quality and generally are suitable for all beneficial uses including irrigation, municipal water supply, and maintainence of aquatic life.

Eastward of the Rocky Mountains, thick layers of sedimentary rocks occur in combination with low precipitation and higher evaporation rates, resulting in poorer water quality. Major streams in this area, the Teton and Marias Rivers, generally are good to excellent in quality at the head waters, but degrade as they flow eastward and are substantially higher in total dissolved solids in downstream areas. They change from a calcium-bicarbonate type water to an increasing abundance of sodium-sulfate type water.

In central and westcentral Montana there are a number of mountain ranges including the Big Belt, Snowy, and Little Belt Mountains that are headwaters for numerous streams. These headwater streams generally have good to excellent quality. As these streams move onto the plains areas, quality generally

degrades, but still is fair to good. An example of this pattern is the Judith River, which heads in the Snowy Mountains near Lewistown and changes from an excellent quality cold-water fishery to a warm-water fishery as it nears the Missouri River north of Lewistown.

The northcentral and northeastern portion of Montana includes the Milk and lower Missouri River basins. These major rivers have headwaters in mountainous areas and have fair to good water quality. Even the major rivers, however, show an increase in dissolved minerals towards the east. Smaller sub-basins in northcentral and northeastern Montana tend to be moderate to high in total dissolved solids and typically are sodium-sulfate waters with quality declining eastward. In northeastern Montana, Redwater River, Poplar River, and Big Muddy Creek are major streams and typically have fair to very poor quality. These waters tend to be a sodium-bicarbonate-sulfate type. Nearly all the smaller streams are intermittent and have poor quality with sodium-sulfate type water predominant.

The plains area between the Missouri and Yellowstone Rivers contains few perennial streams, and water quality is poor. Waters in this area tend to be high in dissolved solids and are of a sodium-sulfate type.

Surface water quality particularly during low flow periods reflects the general water quality in the area. The vast amount of sampling that has been done on both surface waters and groundwaters in Montana has shown that there is a general correlation between the quality of surface waters and the quality of groundwaters reflecting the overall innerconnection of these hydrologic systems. Groundwater quality tends, overall, to be slightly poorer in quality than surface waters due to the more intimate interaction with earth materials.

Streams in the upper Clark Fork River basin in Montana, and the upper Missouri River basin in Montana, contain excellent waters and have one of the best, if not the finest, trout fisheries remaining in the continental United States. The majority of existing mining and a majority of projected future mining in Montana occurs or will occur in the part of Montana with the highest quality waters that are of national significance for their recreation and fisheries. This clearly presents a resource conflict and puts an emphasis on development of strategies for prevention of mining related impacts on water quality.

MINING, MINERAL FUELS AND THE ECONOMY

Water quality problems caused by mining activities are related to the number, extent and size of operations. The value of minerals produced, industry-wide employment, and tax levels are measures of the importance, economic health, and political influence of the industry. Institutional measures such as taxation, fees, or financial incentives to be used in pollution control may depend on the economic and political status of the industry.

Mining and mineral fuels employment for 1970 to 1976 (Table 1) shows a relatively constant overall employment. There was a decrease in metal mining employment and an offsetting increase in coal, quarrying and non-metallic mining employment. The average weekly earnings for all mining and mineral fuels has increased significantly and is continuing to rise (Table 1).

TABLE 1
MONTANA MINING AND MINERAL FUELS EMPLOYMENT, 1960 to 1976
AND EARNINGS, 1960 to 1974

Year	Annual Average All Mining 1/	Metal 2/	Coal, Quarrying & Non-metalic	Petroleum & Nat. Gas 2/ Extraction	Average 2/ Weekly Earnings, All Mining
1970	6,600	4,000	800	1,800	158.59
1971	5,400	2,900	900	1,600	169.81
1972	6,400	3,700	1,000	1,700	187.65
1973	6,700	3,900	1,200	1,600	198.58
1974	7,500	4,100	1,500	1,300	237.73
1975	6,700	3,100	1,600	2,000	
1976	6,200	2,400	1,600	2,200	

1/Mont. Dept. of Labor, 1977; 2/U.S. Dept. of Labor 1977

Mining and mineral fuels extraction ranked second in weekly wages in 1976. However, the number of workers employed in this sector is only a small segment of total state employment. State employment in 1976 was 305,300, of which 6200, or 2.0 percent, were employed in mining and mineral fuels extraction.

Taxes also are indicative of the mineral industries economic importance. Taxes on minerals and mineral fuels, excluding corporation license tax and property taxes are summarized in Table 2 . The overall taxes paid in 1977 by mining and mineral fuels were about 16 percent of the total state revenue monies (John Clark, pers. comm.). The coal mine tax is about 74 percent of total taxes paid by the mineral industry and over 11 percent of the total state tax revenues for 1977.

TABLE 2

STATE TAXATION OF THE MINERAL INDUSTRY
FISCAL YEAR 1977

Tax Name		Tax Amount
Strip Coal Mine License Tax		34,469,000
Crude Oil Productions & License Tax		6,884,000
Resource Indemnity Trust Account		2,212,000
Micaceous Minerals Tax		10,817
Metalliferous Mines License Tax		527,000
	TOTAL	46,279,817

Source: John Clark pers. comm.

REFERENCES

Clark, John, researcher, Montana Department of Revenue, pers. comm., February, 1978.

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U.S. Department of Labor, 1977, Annual statewide labor force report for 1976.

MINERAL COMMODITIES

Montana's geologic environment has yielded many mineral commodities, which have been mined, concentrated, refined, and used by industry and consumers of the state and nation. A number of minerals today produced in small volumes are expected to be mined in greater tonnages in the future.

Table 3 summarizes much of the data from the individual mineral commodity discussions in Appendix A . Of the 36 minerals occuring in commercially important quantities in the Statewide 208 Area, 25 have been mined in the past or are mined today. A detailed description of each mineral commodity in Montana, its use, characteristics, production, projection, geologic occurrence, Montana occurrence and mines, and water quality problems are in Appendix A .

Twelve mineral commodities will experience the most significant levels of production in Montana in the next 10 to 20 years. These commodities are barite, bentonite, copper, gold, lead, phosphate, sand and gravel, silver, talc, tungsten, vermiculite, and zinc. Other commodities that will experience development, but of a smaller magnitude, in Montana's mineral future will be antimony, fluorspar, gemstones, limestone, silica, and possibly graphite. The expanded development of each mineral will place demands on Montana's environment, and a comprehensive water quality management plan must consider the extent and location of anticipated future mineral production.

TABLE 3

MINERAL COMMODITIES DATA SUMMARY*

Commodity and Method Mined. U-Underground S-Strip O-Open Pit Quarry	Has Been Mined	Being Mined N-None S-Small M-Medium L-Large	Potential for Future Development N,S,M,L I-increased production expected P-proven mineable resources will be developed under right economic circumstances	Is Montana a nationally major supplier?	Nature of existing or potential water quality problems	Comments
Antimony (U)	Yes	S-1 mine	S/I	Yes/but total domestic production is insignificant	Acid mine drainage arsenic	US imports, 1 2 mines suppl most of US pr duction is ir Montana
Arsenic	Smelter By-product	Smelter By-product	Only as smelter by-product	Yes	Acid mine drainage toxic to humans and aquatic life (Mining)	Butte is larg domestic prod
Asbestos (O,U)	Yes	N	N	--	None in Montana; problem if fiber gets into drinking water	US imports
Barite (O)	Yes	S-3 mines	M/I	No	None in Montana; some salts in barium toxic to humans	US is large i ter, but has reserves
Bentonite (S)	Yes	M	L/I	Yes	Sediment, turbidity and dissolved solids	US is self-sufficient: M tana, Wyoming & So. Dakota 90 % of world mineable depc

* For complete discussion of each commodity, see Appendix A

Bismuth	Smelter By-product	Smelter By-product	Only as smelter by-product	No		US imports mc of its needs
Cadmium	Smelter By-product	Smelter By-product	Only as smelter by-product	No		US imports
Chromium (U)	Yes	N	N	--	Possible acid mine drainage from associated ores	US imports 9C of its needs; of US resourc in Stillwater Complex
Clay (S)	Yes	N	S/P	No	Minimal-dissolved solids and suspended sediment	US exports
Copper (U,0)	Yes	L	L/P	Yes	Acid mine drainage	US is largest producer and be self-suffi
Fluorspar (0,U)	Yes	S	M/P	Yes	None in Montana; excess fluoride concentrations in water	US imports 8C its needs
Gems (0)	Yes	S	S/I	Yes	Minor problems in Montana; sediment and turbidity	US imports ar ports, Sapphi most importar Montana gem
Gold (0,U)	Yes	M	M/I	Yes	Severe-sediment from placer Severe-cyanide leaching severe-acid mine drainage	US imports, M tana is 1 of states produc 96% of US gol
Graphite (0,U)	Yes	S	S/I	No	Minimal suspended sediment	US imports

Gypsum & Anhydrite (0)	Yes	S-M	M/I	No	Increased salinity and hardness of water; waste dump erosion problems	US is self-suffici US is largest producer
Iron (0)	Yes	S	M/P	No	Minimal in Montana, can be toxic to aquatic life	US is among major producers
Lead (U)	Yes	S	M/P	No	Acid mine drainage	US is largest producer
Limestone (0)	Yes	M	M/I	No	Minimal-sediment	US is self-suffici
Manganese (U)	Yes	N	S/P	Yes in 1960's	Minimal	US imports
Molybdenum (U,0)	No	N	S/P	--	May significantly affect irrigation water	US exports
Niobium (Columbium) (U,0)	NO	N	N	--	Minimal-sediment	US imports all nee could be self-sufficient
Pegmatite Minerals (U,0)	Yes	S-Feldspar	S/P-Feldspar	No		US exports feldspa US has large reser of scrap and flake mica; US has sufficient reserves c beryllium minerals
Phosphate (0)	Yes	M-1 mine	L/P, expected after 1990	No	Suspended sediment potential problem from uranium associated with phosphate rock	US is self-suffici potential exists f Montana to become major US producer

Sand & Gravel (S)	Yes	L	L/I	--	Sediment and turbidity, alteration of stream channels	US is self-suffi
Silica (0)	Yes	S	M/I	No	Sediment problems	US has large res
Sillimanite Minerals (U,0)	No	N	N	--		Large reserves i
Silver (U,0)	Yes	L-mostly by-product	M/P	Yes	Acid mine drainage	US imports; alon with 2 other sta Montana produces 24% of domestic put
Sodium sulfate (0)	No	N	N	No		US has large res but imports some
Stone (0)	Yes	M	M/I	No	Minimal-sediment	US is self-suffi
Sulfur	By-product	S By-product	Only as by-product	No	Some sulfide minerals produce acid water	US reserves are of world total, imports some
Talc (0)	Yes	M	L/I	Yes	Waste dump erosion problems	US is self-suffi Montana is 4th l est producing st
Thorium & Rare Earths (U,0)	Yes	N	S/I	--	Radioactivity	US has large res
Titanium (0)	No	N	N	--	None in Montana; little known about the problem	US imports but o produce for all needs
Tungsten (0)	Yes	S	L/P	No	None in Montana Metals problem known at California mine	US able to produ 75% of needs

Vermiculite (0)	Yes	L	L/I	Yes	Large disturbance area; past tailings/sedimentation impacts	US largest produ most US producti is from Montana
Zinc (U,0)	Yes	By-product of copper mining	M/P	No	Acid mine drainage	US imports

Production and Projections of Mineral Development

Antimony use in flame retardants is increasing despite the decrease in its use in storage batteries. The U.S. Bureau of Mines (1977) projects an annual growth rate of 4 percent in the rate of antimony use. The Babbitt mine in Sanders County produces half the U.S. domestic primary production, and production at this site is to be increased. Deposits elsewhere in the state are not known.

Use of barite in drilling muds is increasing, and the economics of producing barite domestically are becoming more favorable. Three productive deposits occur in Missoula and Mineral Counties and are operated by small miners. Expanded production from these and other deposits is expected.

Montana, Wyoming, and South Dakota have 95-90 percent of the world's reserves of sodium bentonite, and use of this clay is greatly expanding. Extensive deposits in central and north central Montana are of active interest to industry. Recently, an 1100 acre mine permit application was received by the Reclamation Division. The quality of reclamation of mined bentonite lands is controversial, however, recent research shows that vegetation can re-establish itself in many locations.

Copper has been one of the foundations of the Montana mining economy. Although 99 percent of Montana's past production has occurred at Butte, huge low-grade reserves are found in the Belt sedimentary rocks of northwestern Montana. (These deposits are economically important and may be a source of expanded domestic copper production in the future.). Active exploration efforts also are underway in the Beartooth Mountains and in the Hughesville-Neihart area. Water quality problems (acid mine waters) are associated with pyrite-bearing deposits, but acid waters have not been encountered to date at the proposed ASARCo mine near Bull Lake, a strata-bound deposit.

Gold prices have risen dramatically in the last few years, and there have been varying predictions of its development potential. Of increasing interest in Montana is the leaching with cyanide of waste dumps, tailings and low-grade areas. Several cyanide leach operations have been proposed, and thorough evaluation of these projects will be necessary to ensure environmental protection. Gold may be produced at many mines in Montana if prices continue to rise.

Graphite needs are mostly supplied by foreign sources, and a new graphite mine in Jefferson County is being developed. Other commercial deposits, if found, will be developed.

Lead and Silver production are expected to grow in conjunction with future expansion of copper mining. The occurrence of silver in association with copper particularly increases the interest in a property. Montana has large reserves of zinc, also associated with copper deposits, and growth of zinc production is to be expected. Each of these commodities may be associated with pyrite-bearing ore deposits, and careful evaluation of large and small mining operations is important.

Sedimentary phosphate deposits are found in central western, and southwestern Montana, at the northward extension of valuable deposits in Idaho. It is expected that after 1990, demand for western phosphate will increase, and new Montana mines may open.

Sand and gravel mining is the largest non-fuel mineral industry, in volume, in the United States. In Montana, mining supplies construction activities, and government projects. Major shifts in production are generally caused by availability or lack of government work. Water quality problems associated with sedimentation, discharge, and poor mine siting result from some sand and gravel mining.

<u>Talc</u> production is increasing in the state primarily because Montana's talc contains very little asbestos. Exploration activities are extensive in Beaverhead and Madison Counties.

<u>Tungsten</u> is an important strategic mineral whose major uses are in metal working machinery. Production in Montana has been sporadic and is very small at this time, but there are significant ore reserves. Exploration efforts are extensive throughout western Montana, and increased production is expected.

Almost all <u>vermiculite</u> produced in the United States comes from the W.R. Grace Mine near Libby. Another large mine is proposed for Skalkaho Mountain, Ravalli County. Use of this commodity is expanding rapidly in the construction sector.

Prediction and forcasting of consumption levels and primary demand is a tenuous process. This section of the commodity reports summarize projections made by the U.S. Bureau of Mines (1970, 1977), the U.S. Geological Survey (1973), and some specific commodity reports (Engineering and Mining Journal, 1977; USGS, 1977; and others). Generally, all sources used base projections on past and current levels of consumption and production. This information is helpful in projecting future levels of production in the next 10 to 15 years, but may not be particularly useful in making projections over longer periods of time.

Future levels of consumption will be affected not just by domestic economic forces, but also by international economic trends, domestic governmental policies, and technological advances in recycling and mining methods. Projections into the future can be made based on assumptions that past trends will be mirrored in the future, by developing scenerios of alternative levels of consumption, or by establishing goals for society and outlining policies which

will permit achievement of those goals (Lovins, 1977, p.63-72).

The role Montana will play in meeting United States' mineral demands is only partly determined by rising mineral consumption levels. Substitution and recycling will play ever increasing roles in meeting mineral demands and extending the world's mineral resource base (NATO Science Committee, 1976).

World use of minerals is growing rapidly. Skinner (1976) summarizes the situation:

> The annual per capita consumption of newly mined mineral products for all the peoples of the world now totals 3.75 metric tons. The total includes coal, oil, iron, copper, cement, and a myriad of substances used in countless different ways; the total is still rising, doubling approximately every decade, and there is no sign that it is likely to stop in the near future. If all 1975's newly mined mineral substances were somehow stacked on historic Boston Common, the result would be a column approximately six miles high. By 1985 the annual pile would be 12 miles high.
>
> Annual per capita rates of consumption of mineral products are highest in the countries of the industrialized Western world (15 metric tons in the United States), but the rate of increase is highest in developing countries. We can anticipate that both aspirations and populations of the developing countries will continue to grow, and that consumption of mineral products will follow suit.

Despite the uncertainty of demand projections, it is inevitable that the rate of metal consumption will continue to increase at present rates through the year 2000, because (1) world population growth alone leads to increasing metals demand and (2) rising expectations of underdeveloped and developed peoples will increase per capita metals consumption (NATO Science Committee, 1976).

Although world reserves of aluminum, calcium, chlorine, hydrogen, iron, magnesium, nitrogen, oxygen, potassium, silicon, sodium, and sulphur are abundant and are not cause for world concern, several other minerals are found in short supply in the earth's crust. Among the scarce minerals found in Montana are antimony, copper, lead, platinum, silver, tungsten, and zinc (NATO Science Committee, 1976). It is these minerals that will be the most sought after in the state.

Skinner (1976) has summarized geologic data on the nature of occurrence of many scare minerals. Deposits of present interest of scarce metals are sulfides, oxides, hydroxides and carbonates, minerals which are easily smelted. Skinner (1976) argues that the resources contained in such deposits are fixed, but that significantly larger reserves of the same minerals occur in silicate minerals, which comprise common rock. Both Skinner (1976) and the NATO Science Committee (1976) argue that common rock, or very low-grade mineral deposits, will probably never be mined, because the energy costs drastically increase in mining and smelting of larger volumes of low-grade rocks, particularly stable silicate minerals. There is a point beyond which it is economically, and energy wise, not practical to produce metals, despite the fact that it may be physically possible.

With this scenerio, it is clear that exploration will continue, and perhaps intensify, in search of undiscovered ore bodies, unnoticed or concealed by other rock. The search for metals will continue in western Montana. At the same time, nationally, the search for more abundant substitute metals will expand as will recycling technology. Large low-grade reserves of more common metals may be produced in Montana after the year 2000.

Geologic Occurrence; Montana Occurrence and Mines

The U.S. Geological Survey (1968) in cooperation with the Montana Bureau of Mines and Geology, compiled all available information on known mineral occurrences in Montana. Although some of the data is out of date or incomplete, their report is the best unified reference document on Montana mineral occurrences and mine property locations. The U.S. Bureau of Mines (1970,1977) and the U.S. Geological Survey (1973) have reported on the characteristics, use, levels of production, consumption, and global occurrence of mineral commodities

used by American society. Montana has commercially important deposits of 36 mineral commodities, or 55 percent of the number of mineral commodities used in the nation.

Much of the mineral resource data reported in these studies has been updated by specific reports of the U.S. Geological Survey and the Montana Bureau of Mines and Geology. Additional information has been provided in discussions with members of the Montana Bureau of Mines and Geology (D. Lawson, W. Johns, pers. comm.) and members of the U.S. Forest Service (ranger district discussions). Locations of Montana mines were collected from the records of, and discussions with, the Montana Reclamation Division, U.S. Forest Service, and Montana Bureau of Mines and Geology. Confidentiality restrictions prevented examination of Reclamation Division records concerning small miners in the state. These reports and discussions served as the basis for the mineral resource discussions of this chapter. Greater accuracy in Montana mineral resource information could be obtained from proprietary records of the U.S. Bureau of Mines and exploration mining companies, however, this data is not generally available to resource planners. However, publicly available data is sufficient to indicate the geologic extent of mineralized areas and the regions of anticipated future development.

Water Quality Problems

Water quality impacts of mining of many commodities is dependent on the mining method used. The impacts of strip mining, open pit mining, and underground mining differ in the extent of surface disturbance, the volume of waste material excavated, and the possibilities for mine drainage control. A number of water quality impacts are general to the mining industry, and are not commodity specific. These impacts are discussed in Chapter IX - Mining and Water Quality. Most water quality impacts discussed under each specific commodity in Appendix A , concern chemical impacts to water quality of each specific mineral.

The relationship of water quality and mining is shown in an impact matrix (Table 3A). In this matrix, each commodity mined in Montana is related to its potential effects on water quality. The magnitude and intensity of the impact on water quality is highly variable and is related to methods used for prevention, abatement, or correction. Water quality impact is listed as either small or large and represents a subjective judgement as to the maximum potential impact of a given commodity on a specific water quality parameter. As described in other sections of this report, sedimentation and turbidity problems are common to all types of mining and are listed on the impact matrix only when they appear to be especially important. Similarly, nutrients (nitrogen compounds) are present where explosives are used and nutrient impacts are only shown where they are expected to be unusually large. Oil and grease problems also are common to all mining and are not listed on the impact matrix. Another factor to be considered is that a specific commodity can occur in a variety of deposits that have variable potential for harm to water quality. Copper, for example, can occur in sulfide deposits which can create substantial acid mine drainage, or it can occur as oxides which pose much less of a problem. Commodities produced as a by-product are not listed on the impact matrix.

TABLE 3A IMPACT MATRIX RELATING MINING & WATER QUALITY

COMMODITY MINED	METALS	pH – ACIDITY	SEDIMENT-TURBIDITY	COMMON IONS	NUTRIENTS	OTHER
ANTIMONY	L	L				
ASBESTOS			L			ASBESTOS FIBERS
BARITE						BARIUM
BENTONITE			L	S		
CHROMIUM	S	S				
CLAY			L	S		
COPPER	L	L		L	S	
FLUORINE				S		FLUORIDE
GEMS			S-L			
GOLD (PLACER)			L			
GOLD (LODE)	L	L		L		CYANIDE
GRAPHITE	S ?					
GYPSUM			L	L	S	HARDNESS
IRON	S-L	S				
LIMESTONE		S		S	S	HARDNESS
LEAD	L	L		L		
MANGANESE	L	L		L		
MOLYBDENUM	L	L		L		
NIOBIUM						
PEGMATITE			S			
PHOSPHATE			L	S	L	PHOSPHATE
SAND & GRAVEL			L			
SILICA			S			
SILVER	L	L		L		
SODIUM SULFATE				L		
STONE			S			
TALC			S-L			
THORIUM	S	S				RADIOACTIVITY
TITANIUM			L		S	
TUNGSTEN	S	S				
URANIUM	S-L	S-L	S-L			RADIOACTIVITY
VERMICULITE			L		S	
ZINC	L	L		L		
COAL	S	S	L	L	L	
OIL				L		OIL + GREASE
NATURAL GAS			S-L			METHANE

L = POTENTIAL LARGE IMPACT
S = POTENTIAL SMALL IMPACT
BLANK = NO IMPACT EXPECTED

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MINERAL FUELS

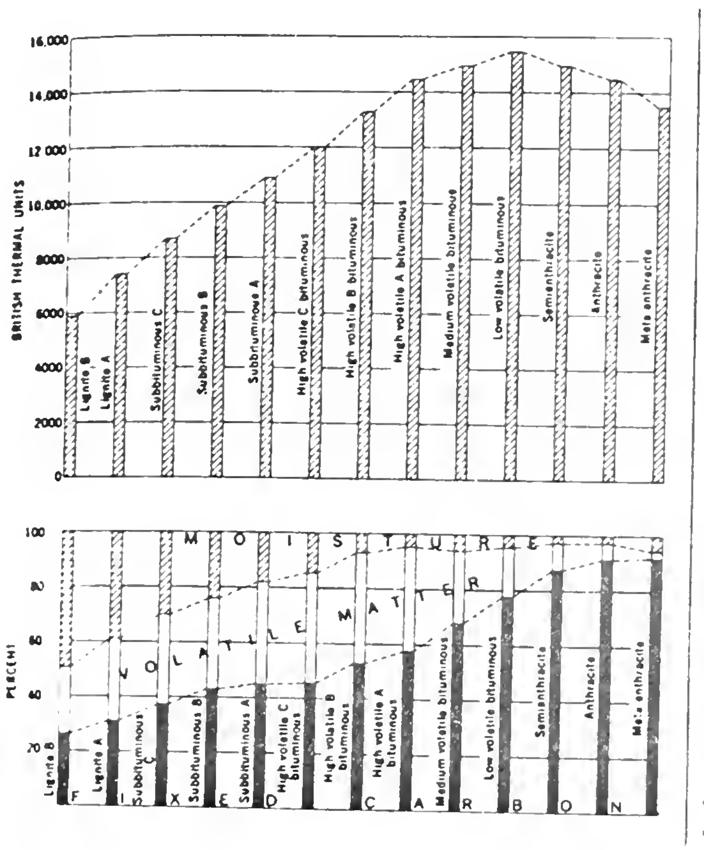
The potential expansion of mineral fuels development in the Statewide 208 Area of Montana is great. There are vast reserves of lignite and possibly natural gas. Oil production has been important since the 1950's and uranium exploration has occurred in diverse physiographic regions of the state.

This chapter outlines the development trends of each mineral fuel, and broadly projects the nature of future developments. Development of each mineral fuel will be affected greatly by national energy and environmental policy. The extent to which natural gas reserves in the Rocky Mountains are developed, and the importance of coal-fired power plants and coal gasification in meeting energy needs of the Pacific Northwest, will hinge largely on federal policy. As Lovins (1977) has pointed out, the United States is at an energy policy crossroads, and Montana's role as an energy producer will be shaped by decisions now made regarding per capita energy consumption and national reliance on alternative energy sources.

COAL

Coal is the compressed and altered residue of plants which grew in ancient swamps. As the accumulation of plant material continued, it was transformed into peat. Further physical and chemical changes of peat compressed and solidified it into coal. Coal contains widely varying amounts of sand, silt, and mud that was washed into these ancient swamps, and this mixture forms the bulk of the ash of burned coal.

Coal is classified by rank according to the percentage of fixed carbon and heat content. Coal resources in the Statewide 208 Area vary from lignite in east-central counties, to bituminous in the Bull Mountains (Figure 2).



USGS, 1973

FIGURE 2: Coal Ranking Criteria

Development Projections

In April, 1977, President Carter released his national energy plan which proposed to double annual coal production by 1985, from the present level of 665 million tons to 1.2 billion tons. The emphasis on coal is part of the plan to substitute abundant energy sources for those in short supply. Although coal comprises 90 percent of United States total fossil fuel reserves, the U.S. meets only 18 percent of its energy needs with coal. Domestic energy needs are mostly met by oil and natural gas, although these fuels account for less than 8 percent of United States reserves. The administration proposes major industrial and utility shifts from oil and gas to coal and other fuels, using coal in an environmentally acceptable manner, and developing and perfecting processes of coal gasification.

A recent report to the Congress by the Comptroller General of the United States (1977), however, concludes that achieving 1.2 billion tons by 1985 is highly unlikely; in fact, it will be very difficult to achieve 1 billion tons by 1985. The report states that although the actual tonnage of coal produced and used has increased through the years, coal use has declined relative to other fuels. Coal is less convenient than alternative fuels and causes more harm to the environment. The report also notes that recent coal prices have not been as attractive as those of other energy resources for a number of reasons, including (1) uncertain environmental standards (both land and air); (2) possible increased capital and operating costs due to environmental control requirements; (3) transportation and storage problems; and (4) the relative cost advantages of nuclear power.

Future production of Montana coal has been discussed in numerous reports. One recent report (FEA, 1977) projects Montana development for 1980 at 43.6 million tons, and 1985 production at 101.1 million tons (Table 4). Most of this production is expected to come from the Powder River basin, outside the Statewide 208 Area.

Lignite development is projected in three areas: (1) Dreyer Brothers' Circle West Ranch, a wholly owned subsidiary of Burlington Northern, Inc., in McCone County, at one million tons per year in 1984, increasing to five million tons per year in 1985 and thereafter; (2) Knife River Mine at Savage, increasing from the present 300,000 tons per year to 400,000 tons per year in 1979 and thereafter; and (3) the Wibaux area.

Another development projection was prepared for the Missouri River Basin Commission (Harza Engineering Company, 1976), and projects various levels of coal production based on energy policy, supply and demand assumptions. Harza's low forecast scenario for Montana coal production is 25.5 million tons per year in 1985 and 2000. The scenario for most probable level of development projects 104.14 mty (million tons per year) (1985), and 268.84 mty (2000). At the high level Montana forecast for 1985 and 2000, 136.3 and 430.1 million tons per year are projected. Harza divides its statewide projections into subregions. The most probable energy development scenario for the eastern Montana lignite area is estimated at 19.49 mty (four mines) in 1985, and 30.88 mty (six mines) in 2000 with no coal gasification plants, and one thermal electric plant with a 50 megawatt capacity. The low energy development scenario projects one mine producing .5 mty in 1985, and, in 2000, supporting one thermal electric plant of 50 megawatts.

TABLE 4

WESTERN COAL DEVELOPMENT MONITORING SYSTEM

QUARTERLY SUMMARY
AUGUST 1977

STATE OF MONTANA

OPERATION	ACTUAL & INDUSTRY PROJECTED CAPACITY: MILLION TONS/PER YEAR											
	75	76	77	78	79	80	81	82	83	84	85	FULL
Big Horn County												
CONSOLIDATED-CX Ranch Project							1.5	3.0	5.0	5.0	5.0	5.0
DECKER East						4.9	6.0	6.0	8.0	8.0	8.0	8.0
DECKER North					2.0	2.0	3.0	3.0	4.0	4.0	4.0	4.0
DECKER West	9.1	9.1	10.1	10.5	10.5	10.5	11.0	11.0	11.0	11.5	11.5	11.5
NERCO Spring Creek 1/						3.0	7.0	10.0	10.0	10.0	10.0	10.0
SHELL OIL Pearl							1.0	2.0	2.0	2.0	2.0	2.0
WESTMORELAND Sarpy Creek Track II 2/							2.0	2.0	4.0	4.0	4.0	4.0
WESTMORELAND Sarpy Creek Track III 2/	4.0	4.1	5.5	5.5	5.5	5.5	10.0	10.0	10.0	10.0	10.0	10.0
County Total	13.1	13.2	15.6	16.0	18.0	25.9	41.5	47.0	54.0	54.5	54.5	54.5
Crow Reservation												
AMAX East Sarpy Creek 3/							5.0	5.0	5.0	5.0	5.0	5.0
SHELL OIL Youngs Creek 4/								4.0	6.0	8.0	10.0	10.0
County Total							5.0	9.0	11.0	13.0	15.0	15.0
McCone County												
DREYER BROS. Circle West 5/										1.0	5.0	5.0

1/ NERCO is a subsidiary of Pacific Power & Light
2/ WESTMORELAND Sarpy Creek Tracks II and III are on Crow ceded lands (Track III is known as the Absoloka Mine).
3/ Crow Tribe must still accept AMAX's final proposal.
4/ Schedule may be abandoned unless Crow can negotiate a plan for royalties and reclamation by 1982. Also, DOI Secretary must lift ban on lease sales of Indian lands.
5/ DREYER BROS. is a subsidiary of Burlington Northern, Inc.

WESTERN COAL DEVELOPMENT MONITORING SYSTEM

QUARTERLY SUMMARY
AUGUST 1977

STATE OF MONTANA

OPERATION	ACTUAL & INDUSTRY PROJECTED CAPACITY: MILLION TONS/PER YEAR											
	75	76	77	78	79	80	81	82	83	84	85	FULL
Musselshell County												
BURLINGTON NORTHERN, INC. Unnamed						0.3	0.6	0.9	1.2	1.2	1.2	1.2
Richland County												
KNIFE RIVER Savage	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Rosebud County												
PEABODY Big Sky	2.3	2.4	2.4	2.5	3.0	3.0	3.5	4.0	4.5	4.5	5.0	5.0
WESTERN ENERGY Colstrip 1-4 6/	6.4	9.3	9.3	10.2	11.2	14.0	14.0	14.0	17.0	18.9	20.0	20.0
County Total	8.7	11.7	11.7	12.7	14.2	17.0	17.5	18.0	21.5	23.4	25.0	25.0
Total	22.1	25.2	27.6	29.0	32.6	43.6	65.0	75.3	88.1	93.5	101.1	101.1

6/ Northern Cheyenne Indians have courtsuit pending to change air quality classification from Class II to Class I. Colstrip Units 3&4 are still planned for construction and possible completion by 1982.

Transportation is a major factor in the pattern of coal-based development occurring in Montana. As a component of a major energy policy study carried out by the Montana Energy Advisory Council, Dr. Paul E. Polzin, consulting economist, prepared a report entitled "Montana's Major Energy Transportation Systems: Current Conditions and Development". This report essentially concluded that given railroad access to needed capital, the theoretical capacity of the Burlington Northern mainline from Forsythe east, with a double track line and centralized track control, is about 220 million tons of coal per year, enough to carry the entire projected annual output of Montana coal for the next 30 years with sufficient leeway to allow significant amounts of Wyoming coal to be routed through the state toward the upper midwest.

Another factor important to lignite and subbituminous coal development is the posture of national policy regarding synthetic fuels production. In the absence of a major federal program to subsidize this development, the Montana University Coal Demand Team (1976) stated; "Our most likely projection is for neither coal gasification nor significant substitution of coal for natural gas". (p.75)

Another factor relating to the national or regional market for Montana coal relates to the pressing debate on the level of pollution control equipment which will be required by the federal government. The President's national energy plan states; "The administration has taken a position that all new facilities, including those that burn low sulfur coal, should be required to use the best available control technology". One of the advantages which has been cited for western coal is its low sulfur content. The advantage to the utility in using lower sulfur coal is that the utility can reduce its investment in pollution control equipment and still

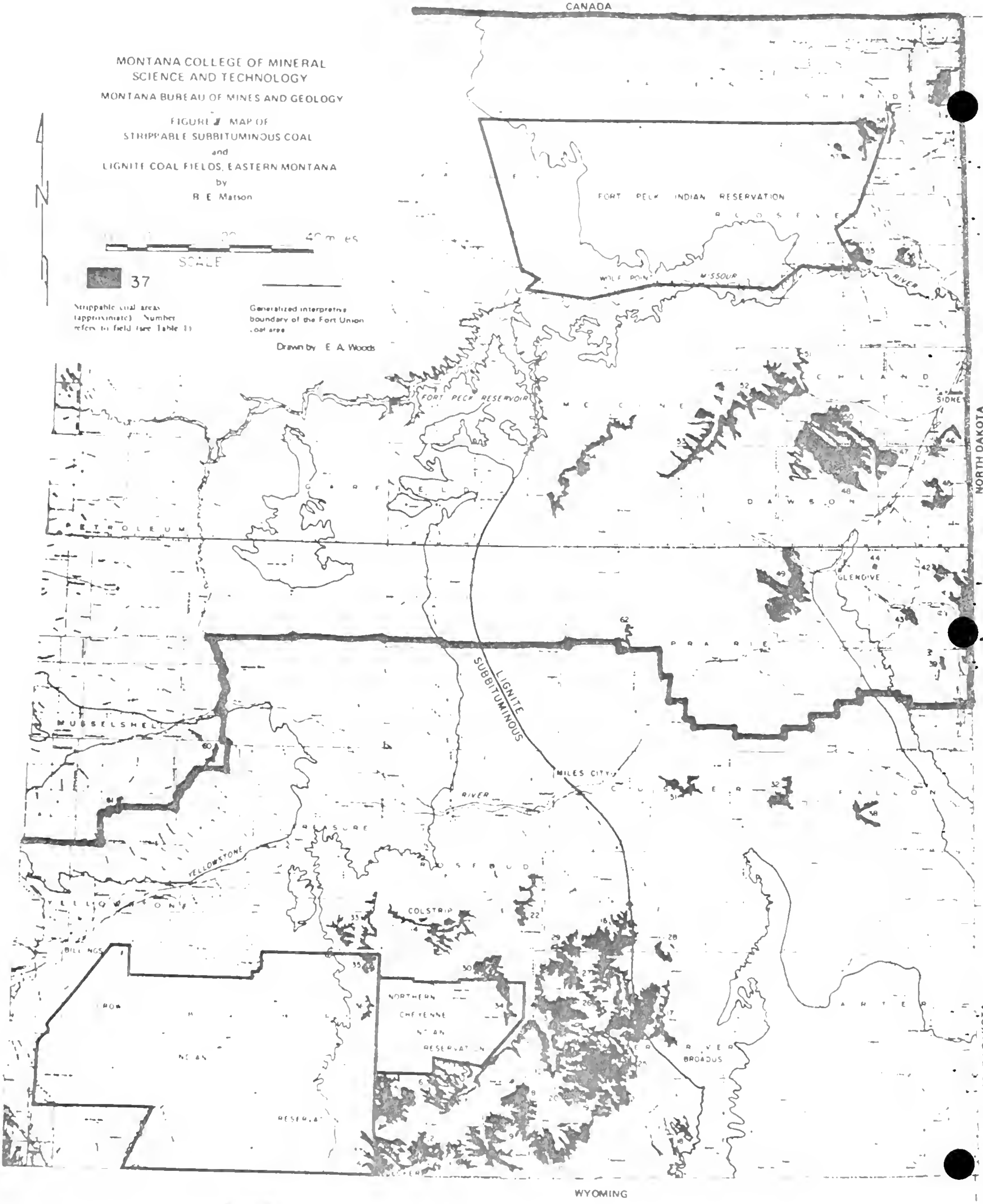
meet standards through the utilization of lower sulfur western coal. If, however, utilities are required to use the best available technology, demand for lower sulfur western coal may relax and higher sulfur eastern coal may be substitued for western coal.

Another factor with some potential in Montana relates to two major proposed pipelines crossing the state. The first is the proposed Northern Border Pipeline which will connect the Alcan Pipeline and bring Alaskan gas into the northern tier, midwest, and eastern states. This line, if constructed, will cross diagonally in a southeasterly direction across the northeastern corner of the state. A major gasification complex in the Fort Union lignite fields within proximity to this pipeline could conceivably feed its product into the line. High BTU synthetic gas is essentially equivalent to natural gas. Another possibility relates to the proposed Northern Tier Crude Oil Pipeline which would cross the state from west to east bringing crude oil to Montana refineries and also to the Chicago refining area from the west coast. There is potentially the opportunity for synthetic crude oil produced in Montana to be introduced into the line for shipment to consuming areas to the east.

Montana Occurrence

In Montana, vast reserves of coal and lignite occur in much of the eastern and north-central parts of the state (Figure 3). At the present time, development is focused on the Powder River Basin, outside the Statewide 208 Area, where there are thick, continuous seams of subbituminous coal. Major lignite deposits are generally found east of Miles City. The Bull Mountain area north of Billings has reserves of subbituminous coal, as

Figure 3



Statewide 208
Study Area

MONTANA BUREAU OF MINES AND GEOLOGY

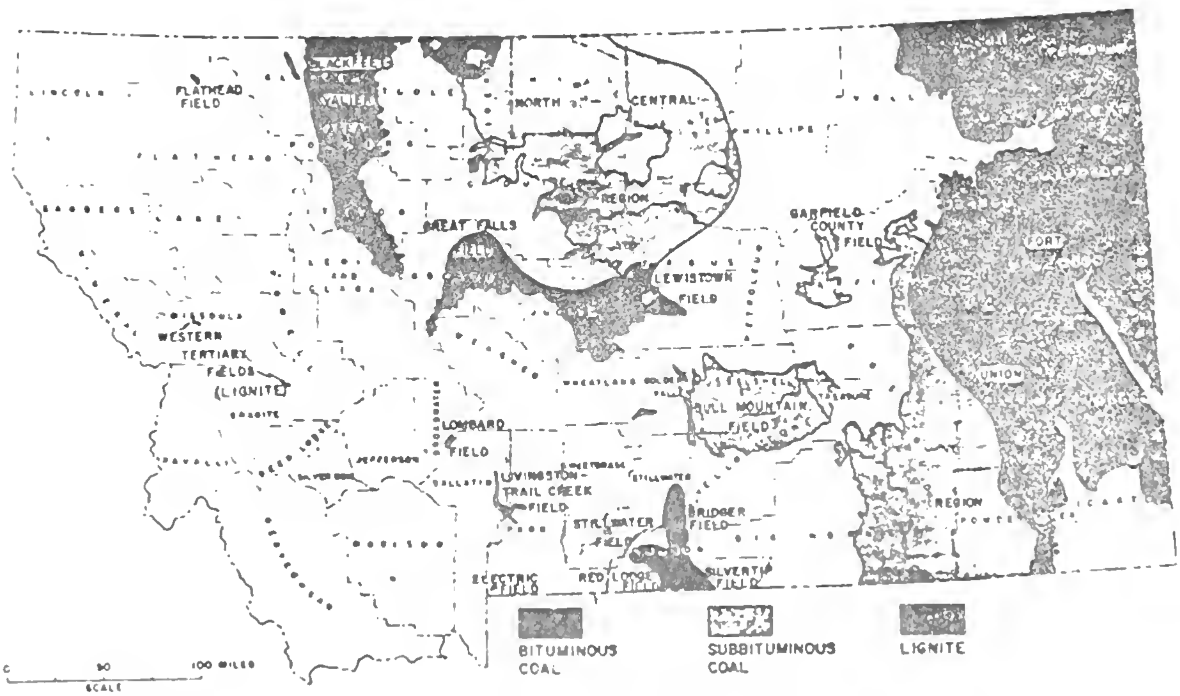
Table 5 – Strippable subbituminous and lignite coal fields, eastern Montana

No. on map	Name of field	Coal bed	Est. reserves in millions of tons	Acreage	Average tons/acre	Ash[1]	Sulfur[1]	Btu[1]
1	Decker	Anderson-Dietz 1&2	2,239.99	25,523	87,763	4.0	.40	9,652
2	Deer Creek	Anderson-Dietz 1&2	495.65	14,214	35,397	4.0	.50	9,282
3	Roland	Roland	218.04	12,076	18,055	9.2	.74	8,164
4	Squirrel	Roland	133.41	6,208	21,490	5.5	.29	7,723
5	Kirby	Anderson	216.52	5,655	38,285	4.2	.32	8,328
		Wall	473.69	5,952	79,579			
		Dietz	834.35	17,516	47,630	5.8	.59	8,509
		Canyon	158.53	4,066	38,983	5.8	.24	8,789
6	Canyon	Wall	1,884.25	23,859	78,974	4.6	.30	9,088
		Brewster-Arnold	65.86	2,067	31,859	7.5	.40	8,444
7	Birney	Brewster-Arnold	180.55	6,969	25,905	5.1	.41	9,055
8	Poker Jim Lookout	Anderson-Dietz	872.65	19,609	44,501	5.2	.37	7,925
9	Hanging Woman Cr.	Anderson	1,583.29	30,547	51,830	4.9	.29	8,496
		Dietz	1,120.96	43,654	25,678	5.5	.33	8,078
10	West Moorhead	Anderson	883.74	19,660	44,949	5.3	.36	8,296
		Dietz	397.49	20,416	19,469	4.1	.41	7,990
		Canyon	690.19	22,547	30,611	5.6	.45	8,055
11	Poker Jim O'Dell	Knobloch	373.29	7,8[illegible]0	47,311	5.1	.22	8,846
		Knobloch	564.78	7,187	78,581			
12	Otter Creek	Knobloch	2,075.55	25,791	80,475	4.7	.36	8,468
13	Ashland	Knobloch	2,696.20	27,200	99,125	4.8	.15	8,421
		Sawyer A & C	357.49	20,262	17,643	4.9	.49	7,883
14	Colstrip	Rosebud	1,439.26	33,379	43,118	8.5	.75	8,750
15	Pumpkin Creek	Sawyer	2,426.50	45,695	53,102	7.5	.34	7,438
16	Foster Creek	Knobloch	708.13	27,801	25,470	7.8	.76	7,573
		Terret	460.87	27,462	16,782	5.8	.21	7,770
		Flowers-Goodale	258.90	14,44[illegible]	17,924	7.8	.51	7,553
17	Broadus	Broadus	739.82	18,429	40,142	7.2	.27	7,437
18	East Moorhead	T	525.21	15,559	33,756	6.2	.57	7,120
19	Diamond Butte	Canyon	418.02	21,363	19,566	4.8	.43	7,350
20	Goodspeed Butte	Cook	628.95	13,446	46,775	10.6	1.63	6,771
21	Fire Gulch	Pawnee & Cook	336.69	8,486	39,674	[illegible].8	.33	7,739
22	Sweeney-Snyder	Terret	326.33	10,921	29.880	9.1	.11	8,175
23	Yager Butte	Elk & Dunning	1,175.86	26,924	43,673	4.8	.33	7,646
		Cook	312.02	14,507	21,507	6.7	.63	7,254
24	Threemile Buttes	Canyon & Ferry	225.40	13,836	16,289	5.5	.94	6,867
25	Sonnette	Pawnee	320.25	8,224	38,940	9.8	.88	6,964
		Cook	362.98	10,470	34,668	8.1	1.23	6,891
26	Home Creek Butte	Canyon & Ferry	217.21	4,851	44,774			
27	Little Pumpkin Creek	Sawyer A&C, D, X, & E	215.83	8,534	25,290			
28	Sand Creek	Knobloch	267.34	5,952	44,915	6.6	.30	7,340
29	Beaver-Liscom	Flowers-Goodale & Terret	135.87	8,851	15,350	8.1	.96	8,102
		Knobloch	491.62	17,075	28,791	7.7	.50	8,027
30	Greenleaf-Miller Creek	Rosebud, Knobloch, and Sawyer	453.71	14,918	30,413	7.5	.71	8,422
31	Pine Hills	Dominy	193.87	6,022	32,191	7.2	.53	7,293
32	Knowlton	Dominy (M & L)	747.51	19,613	38,112	7.1	.41	6,710
		Dominy (U)	120.31	4,448	27,048	5.6	.38	6.645
33	Sarpy Creek	Rosebud-McKay	1,500.00	42,373	35,400	9.0	.[illegible]7	8,450
34	Cheyenne Meadows	Knobloch	1,200.00	13,560	88,500	4.1	.40	8,400
35	Little Wolf	Rosebud-McKay	314.00	7,411	42,370			
36	Jeans Fork		90.00	3,800	23,685			
37	Wolf Mountains		1,922.00	31,000	62,000			
38	Lame Jones	Dominy	150.00	10,593	14,160			6,0[illegible]0
39	Lainesteer	Harmon(?)	35.00	1,978	17,700			6,332
40	Wibaux	C	643.00	18,518	34,720	7.9	.90	6,050
41	Little Beaver	C	134.00	8,445	15,865			
42	Four Buttes	C	91.00	5,180	17,570			6,140
43	Hodges		10.00	807	12,390			
44	Griffith Creek		10.00	568	17,700			

Table 5-Strippable subbituminous and lignite coal fields, eastern Montana

No. on map	Name of field	Coal bed	Est. reserves in millions of tons	Acreage	Average tons/acre	Ash[1]	Sulfur[1]	Btu[1]
45	Smith-Dry Creek	G	150.00	8,475	17,700			
46	O'Brian-Alkalie Creek		150.00	8,475	17,700			
47	Breezy Flat	Pust	406.00	19,832	20,472	6.7	.50	6.660
48	Burns Creek-Thirteenmile Creek	Pust	6,351.00	133,693	47,504	7.8	.65	6,138
49	Southwest Glendive		1,000.00	37,664	26,551	10.7	.33	6,320
50	Fox Lake	Pust	393.00	18,282	21,497	7.8	.65	6,138
51	Lane	Lane	561.00	44,582	12,390			7,150
52	Carroll	Carroll	345.00	29,780	11,584	5.5	.30	7,400
53	Redwater River	S	642.00	24,181	26.550	6.1	.40	7,400
54	Weldon-Timber Creek	S	724.00	25,565	28,320	5.9	.40	7,525
55	Fort Kipp	Ft. Kipp-Ft. Peck	331.00	14,500	22,830	4.6	.20	6,110
56	Lanark	Lanark	100.00	3,531	12,390	6.3	.40	6,853
57	Medicine Lake		58.00	3,740	15,510	7.2	1.00	6,870
58	Reserve		246.00	18,231	13,495	7.6	.40	6,599
59	Coal Ridge	Coal Ridge	150.00	19,200	17,700	7.5	.40	5,830
60	Carpenter Creek	Carpenter	50.00	3,211	14,015	6.5	.40	9,270
61	Charter	Mammoth	60.00	3,210	17,700	6.0	.90	10,1[illegible]0
62	Little Sheep Mtn.	A&C	200.00	10,272	19,470			
		TOTAL	50,040.93	1,340,736				

[1] "As received" basis (where more than one sample available, figures given are average figures).



INDEX MAP OF MONTANA COAL FIELDS

do portions of Hill, Blaine, Liberty, Choteau and Fergus Counties. Much of the coal in these areas occurs in seams less than 30 inches thick and is discontinuous. Smaller areas along the front of the Rocky Mountains near the Canadian border and also between Great Falls and Lewistown have discontinuous deposits of bituminous coal. Present activity in these areas is lmited and small. The total coal reserve base of Montana is estimated to be 108 billion tons, which amounts to over 25 percent of known coal reserves in the entire United States.

Coal fields of the Statewide 208 Area with high or moderate potentials for development, include the Bull Mountains (Musselshell); North Central field (Liberty, Hill, Blaine, Choteau); Wibaux field (Wibaux); Little Beaver field (Wibaux); Four Buttes field (Wibaux), fields in Dawson and Richland Counties; the Redwater River area (McCone and Dawson); Weldon-Timber Creek field (McCone) (Table 6).

TABLE 6

COAL FIELDS IN THE MONTANA STATEWIDE 208 AREA

Field	County	Potential for Development * In Next Ten Years
Garfield	Garfield	Low (some exploration)
Bull Mountain	Musselshell - Yellowstone	Moderate - existing small mines. additional exploration - considerable leasing
Electric	Park	Low
Livingston - Trail Creek	Park	Low
Lombard	Broadwater	Low
Great Falls	Cascade	Low
Lewistown	Fergus - Judith Basin	Low
North Central	Liberty-Hill-Blaine - Choteau	Moderate - planned small mines - exploration activities
Blackfeet - Valier	Glacier - Pondera - Teton	Low
Western Tertiary Fields	Missoula - Granite	Low
Lamesteer	Wibaux	Low
Wibaux	Wibaux	Moderate - high, planned gasification facilities - intensive exploration activities
Little Beaver	Wibaux	"
Four Buttes	Wibaux	"
Hodges	Dawson - Wibaux	Low
Griffith Creek	Dawson	Low
Smith - Dry Creek	Wibaux - Richland	Low
O'Brien - Alkali Creek	Richland	Low

Breezy Flat	Richland - Dawson	Moderate - existing mine - exploration activities
Burns Creek - Thirteen Mile Creek	Dawson - Richland	Moderate
Southwest Glendive	Dawson	Moderate
Fox Lake	Richland	Moderate - intensive exploration - and leasing activities
Lane	Richland	Moderate
Carroll	Richland - Dawson	Moderate
Redwater River	McCone - Dawson	Moderate
Weldon - Timber Creek	McCone	High - planned fertilizer plant - and other conversion facilities
Fort Kipp	Roosevelt	Low
Lanark	Roosevelt	Low
Medicine Lake	Sheridan	Low
Reserve	Sheridan	Low
Coal Ridge	Sheridan	Low
Little Sheep Mtn.	Prairie - McCone - Garfield	Low - moderate - considerable exploration and leasing

* (MEAC, 1976) (DSL, pers. comm.)

NATURAL GAS

The first producing natural gas well was drilled in 1905 to about 2800 feet by M.D. Cassidy who used the gas for heat and lighting in his house (USGS, 1968). The majority of the known gas reserves in Montana are located in the eastern and north central portions of the state. In 1975, it was estimated by the American Gas Association that there was a total proven reserve of 930 bcf (billion cubic feet) of natural gas, which amounts to a 17-year supply at the 1975 withdrawal-from-storage rate. The major gas fields occur between Cutbank and Glasgow (Figure 4).

Much of the natural gas used in Montana is imported from Canada. There are 11 utilities in Montana that distribute gas; Montana Power and Montana-Dakota Utilities are the major suppliers. Canadian natural gas accounts for approximately 73 percent of the total sales of the Montana Power Company. Reduction in import gas volumes from Canada is causing substantial concern for the state's natural gas supply,

> Natural gas consumption has increased significantly over the last two decades in Montana. The industrial sector has shown the fastest growth in gas use, and is the largest and most variable consuming class. Seventy-six percent of industrial gas use is within the Montana Power Company system and is heavily concentrated in a very few industries (Wheeling, 1976, p.9).

Natural gas prices have greatly increased in the past few years in Montana making conversions to alternative fuels more attractive.

Exploration and development for natural gas is continuing in the state with a number of discoveries and new field extensions primarily in the north-central portion of the state in Chouteau, Glacier, Hill, Liberty, Pondera, and Toole Counties and important gas developments in the Bowdoin Dome, and the Bearpaw Arch in Phillips and Blaine Counties. Production, average

FIGURE 4

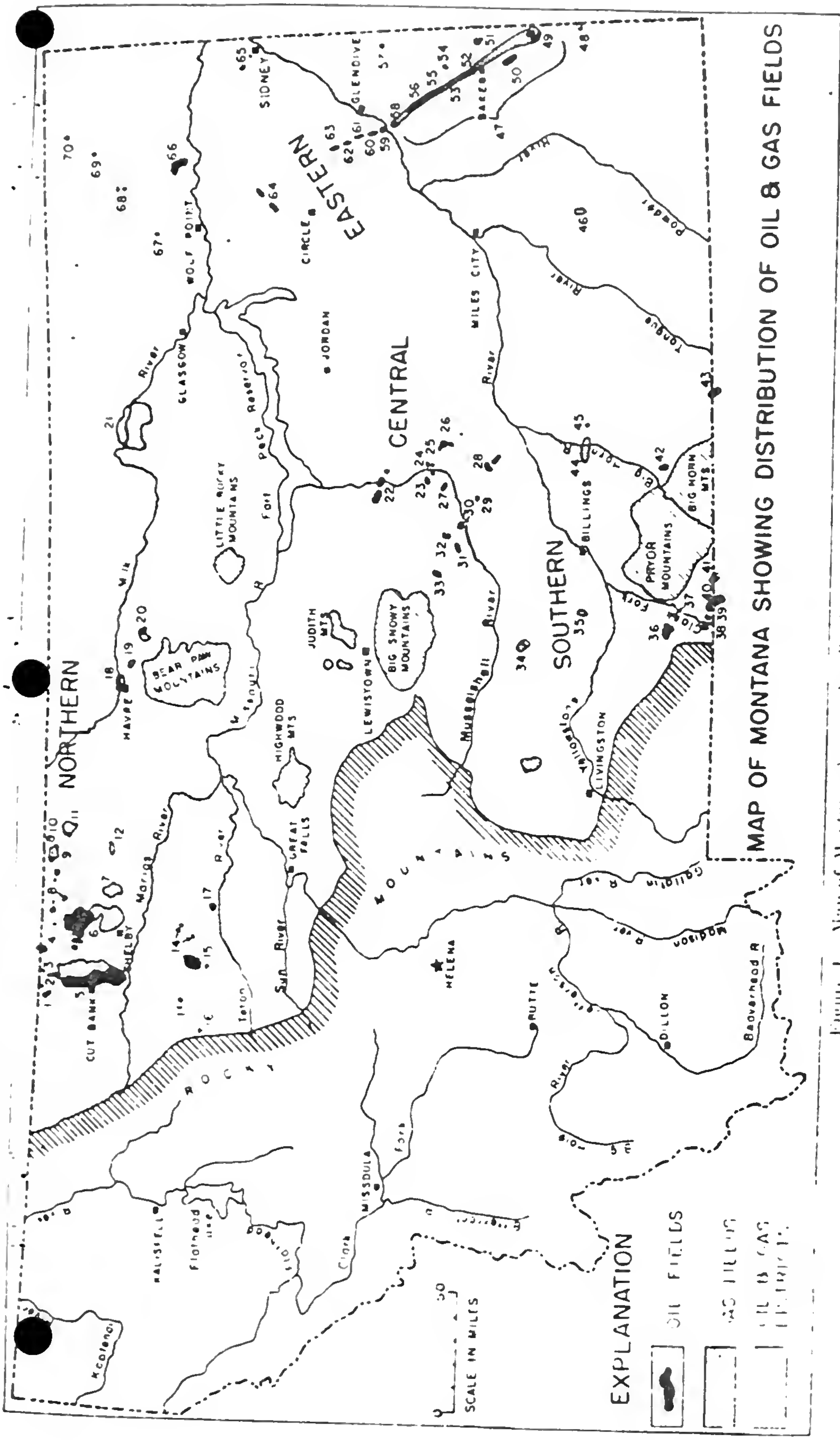


Figure 1. Map of Montana showing distribution of oil and gas fields.

(Perry, 1960)

wellhead price, and distribution of natural gas in Montana is summarized in Table 7 . It shows a large increase in natural gas distribution, a small increase in production, and a large increase in average wellhead price.

The most important factor for future development of natural gas in Montana is the potentially vast undiscovered resources lying in the Overthrust Belt in the Rocky Mountains. The Oil and Gas Journal calls the region "the hottest new area for drilling in the U.S. offshore or on". The area of interest for natural gas development shown in Figure is basically a north-south trending area, along the Rocky Mountains in western Montana. Ibraham (1977) concluded that in addition to the approximately 930 bcf of proven gas reserves in Montana, there are at least two trillion cubic feet of gas in the undiscovered or inferred resources categories and potentially as much as 7 trillion cubic feet. Much of these undiscovered or inferred reserves are associated with the Overthrust Belt. Major discoveries in the Overthrust Belt have been made in Alberta and Utah in similar geologic formations. There is current work being done by the USGS on the Overthrust Belt potential (George Krempasky, pers. comm, 1977). The extent of gas interest in Montana is shown by the large acreages under application for oil and gas leases from various national forests in Montana (Figure 5). As shown on Table 8A, the Gallatin, Beaverhead, Flathead, and Lewis and Clark forests are the center of interest. Lewis and Clark forests have recently released an environmental assessment review which recommends leasing portions of the Crazy Mountains. Areas north of the Absaroka Range and east of Livingston are already leased, and exploration drilling has been proposed for the West Yellowstone area.

TABLE 7

Production, Average Wellhead Prices and Distribution of Natural Gas in Montana

Year	Production[1] (MMCF)	Production[2] (MMCF)	Average Wellhead[2] Price (cents/MCF)	Natural Gas[2,3] Distributed (MMCF)
1950	39708	39010	5.0	29616
1951	39038	36123	5.3	31448
1952	30409	27939	5.7	34742
1953	31779	28592	6.3	34365
1954	31150	29765	6.0	35070
1955	30468	30227	5.2	36409
1956	29356	28350	6.1	41121
1957	32979	31413	6.0	41421
1958	31327	27689	6.5	31947
1959	31585	30551	6.0	44471
1960	35381	30411	6.8	43490
1961	34884	32407	6.4	46072
1962	28973	29417	6.1	50534
1963	27113	25504	6.6	49694
1964	25234	23592	6.6	53323
1965	27873	26285	6.5	58791
1966	32414	29041	8.1	60953
1967	31619	29276	7.9	60560
1968	31917	28831	8.8	57249
1969	41229	37804	7.2	66856
1970	37445	35225	8.1	67252
1971	38137	28775	8.2	74236
1972	35606	32171	10.0	72831
1973	58896	56383	15.9	72184
1974	51401	41753	25.2	NA
1975	44546	NA	NA	NA
1976	44213	NA	NA	

[1] Source: Montana Oil and Gas Conservation Division

[2] Source: Montana Department of Revenue

[3] Data is for fiscal year ending June 30 of year shown

Source: Montana Oil and Gas Conservation Division, as reported by the Montana Energy Office

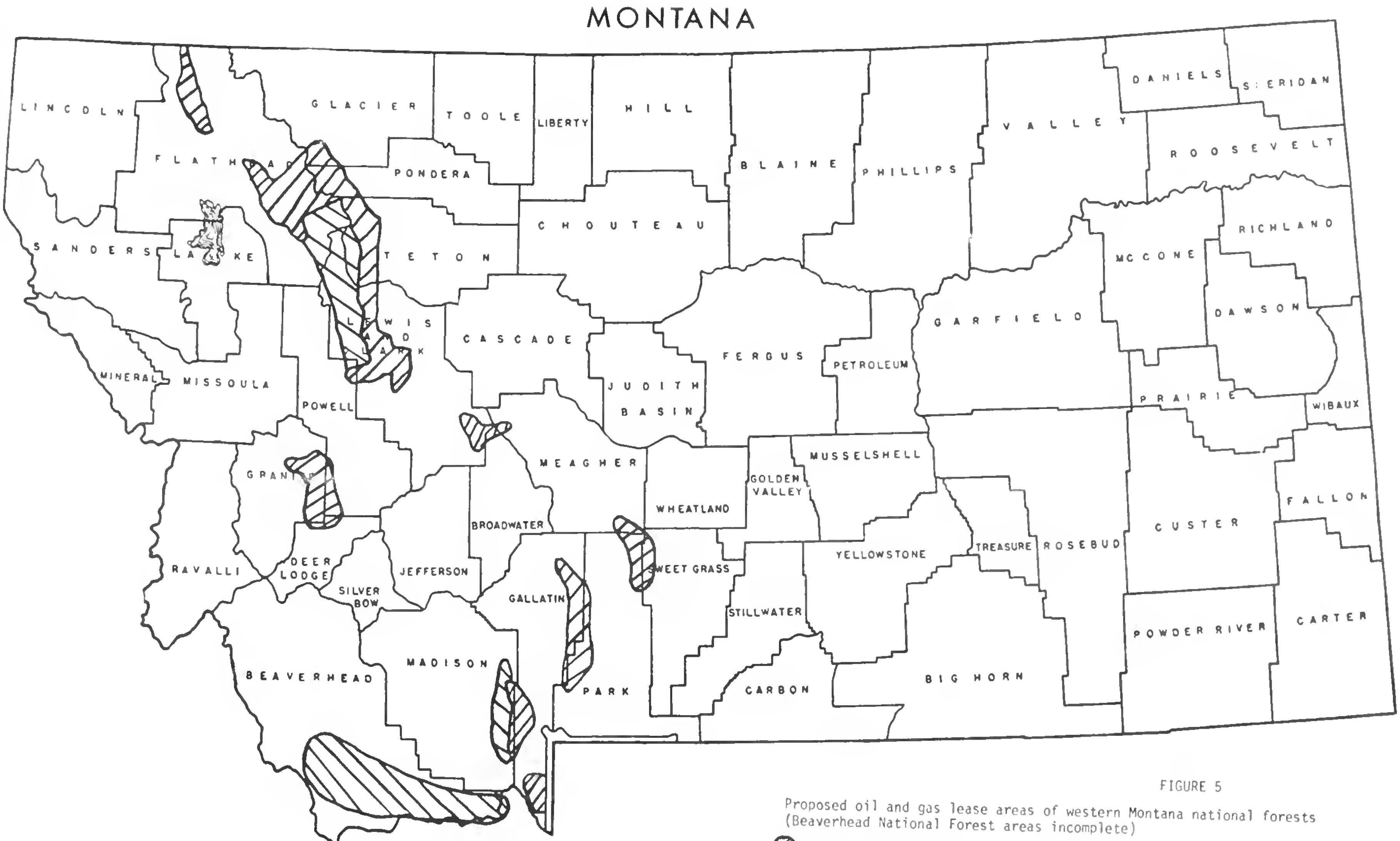


FIGURE 5

Proposed oil and gas lease areas of western Montana national forests (Beaverhead National Forest areas incomplete)

Proposed lease areas

Other high potential areas

TABLE 8A

OIL AND GAS LEASING ACTIVITY
IN NATIONAL FOREST LAND
IN WESTERN MONTANA

Forest	Acres already leased	Acres applied for
Beaverhead	up to 350,000	about 750,000
Deer Lodge	one lease	about 185,000
Flathead	0	about 500,000
Gallatin	70,000	entire forest except Absaroka Range
Helena	0	about 100,000
Lewis and Clark	19,697	571,000
Lolo	0	about 10,000

Natural gas reserves are unproved in the Overthrust Belt, but the interest is obvious. The level of development of these reserves could have significant impacts on mountain environments, including water quality.

Following is a review of the location of oil and gas lease activity on each National Forest:

Beaverhead: in the past few years, about 350,000 acres were applied for in the forest. The forest has recommended approval of all leases with "no surface occupancy" conditions. It is uncertain at this time just how many leases were accepted by industry under those conditions. An additional 400,000 acres has been applied for with no recommendation from the forest at this time. The forest-wide land use plan EIS makes no specific reference to oil and gas development plans, so currently published data is inadequate to assess oil and gas/roadless area conflicts.

Deerlodge: lease areas applied for are in the Flint Creek Range and portions of the Sapphire Mountains; about a fifth of the applied for area is roadless.

Flathead: applied for areas include most lands between the continental divide and the South Fork Flathead River, including many portions of the Great Bear Wilderness Study Area, lands between North Fork Flathead River and the Whitefish Range, the Salish Mountains southwest of Kalispell, and portions of the northern Mission Mountains. The status of leasing within the Bob Marshall Wilderness Area is uncertain, however, much of it is considered "high potential hydrocarbon development potential" by a recently published USGS open-file report.

Gallatin: the forest has already leased an area north of the Absarokas (in the foothills) and some lands around West Yellowstone. One company planned to drill an exploration hole at West this fall but their USGS approval has been delayed. An EAR has just been completed for 62,000 acres of applications in the Crazy Mountains within the Fallatin, and an additional 19,500 acres within the Lewis and Clark. The EAR recommends approval of a portion of these applications, all with "no surface occupancy" provisions. Chevron has already leased 150,000 acres of private land surrounding the Crazies. Drilling interest is centered on the lands surrounding the granitic intrusion which underlies the central core of the Crazies. Chevron desires to tie up all lands in the area, however, and will accept the no surface occupancy condition. The rest of the forest, including roadless areas in the Gallatin, Bridger, and Madison Ranges has been applied for.

Helena: half of the Scapegoat Wilderness, as well as roadless lands adjacent to it are under application. Other interst centers in the Belt Mountains surrounding, and south of, Gates of the Mountains Wilderness.

Lewis and Clark: all portions of the Rocky Mountain Front unit are under application, with 90,000 acres recommended in a just published land use plan. All roadless lands are to be no surface occupancy. Existing leases are in the Highwood Mountains.

Lolo: Lands between Clearwater Junction and the Scapegoat Wilderness are under application, as well as isolated sections in the Bitterroot Valley.

OIL

The oil history of Montana dates as far back as 1864, when an oil seep was found by a wagon trail crossing the Pryor Mountains on the Bozeman Trail. The first attempt to drill for oil was in the late 1800's when Thomas Cruse drilled an 1100 foot dry hole in the Judith River Formation (USGS, 1968). Major oil producing areas in the Statewide 208 Area are near Cutbank, in Pondera and Teton Counties; near Wolf Point, east of the Big Snowy Mountains, and west of Sidney (Figure 4). Commercial oil has come from more than twenty different geologic formations in Montana which range in age from Ordovician to Cretaceous. Oil is produced from a variety of limestone, dolomite and sandstone reservoir rocks. Depths to these producing formations range from a few hundred feet to over 12,000 feet, with the deeper fields in the eastern part of the state (Perry, 1960).

Exploration activities have continued throughout Montana. In 1976, 787 wells were drilled, which resulted in 17 new oil and 8 new gas field discoveries and 11 significant field extensions, in the northern tier counties and the Williston Basin.

The production of oil in Montana from 1950 to 1976 (Table 8) shows a rapid increase in production in the 1950's, a peak in 1968, and a subsequent decline. The wellhead price of oil (Table 8) remained relatively constant until 1970, then doubled from 1973 to 1974. Crude oil reserves in Montana had increased for a number of years, peaked in 1958 at 337,799,000 barrels, and subsequently declined until in 1976 crude oil reserves were 152,670,000 barrels of oil. According to Wheeling (1976),

Montana proven reserves of crude petroleum as of December 31, 1975 are variously estimated at from 164 million barrels by the American Petroleum Institute (API) to 255 million barrels by the Montana Department of Natural Resources and Conservation (DNRC). At 1975 production levels, this would leave the state with some five to seven years of production until presently known recoverable reserves are depleted.

Montana imports and exports large volumes of crude; imports primarily come from Wyoming and Canada.

Three refineries in the Billings area account for nearly 90 percent of the total refinery output in the state. With announced reduction in Canadian crude available to the United States several proposals including large pipelines transecting Montana carrying crude oil are being considered. The U.S. shortage of crude oil has spurred a great deal of exploration and development activity in Montana and it is expected that this activity will continue and probably increase in the foreseeable future. The water quality aspects of petroleum and exploration development are described in Chapter XI

TABLE 8

Crude Oil Production (1000 barrels) and
Average Wellhead Prices (Dollars per barrel)
in Montana

Year	Production[1] of Crude Oil	Wellhead[2] Price
1950	8109	2.52
1951	8958	2.47
1952	9060	2.25
1953	11920	2.18
1954	14195	2.20
1955	15654	2.26
1956	21760	2.58
1957	27122	2.70
1958	27957	2.65
1959	29857	2.56
1960	30240	2.41
1961	30906	2.42
1962	31648	2.42
1963	30870	2.44
1964	30647	2.43
1965	32778	2.43
1966	35380	2.44
1967	34959	2.5[illegible]
1968	48460	2.5[illegible]
1969	43954	2.69
1970	37879	2.78
1971	34599	3.01
1972	33904	3.07
1973	34620	3.33
1974	34554	6.65
1975	32844	7.83
1976	328[illegible]	NA

Source: 1/ Montana Oil and Gas Conservation Division, as reported by the Montana Energy Office

2/ U.S. Bureau of Mines

URANIUM

Uranium is a silvery white metal that consists of the three semistable radioactive isotopes U^{238}, U^{235}, and U^{234}. It can be used in nuclear reactions. Major uses for uranium are for atomic power and nuclear weapons. Small amounts are used in the chemical, ceramics and electrical industries. Prior to 1942, uranium was used mostly for coloring glass and ceramic glazes (USGS, 1973).

Since military requirements for uranium are classified, information is only available on its peaceful uses. At the present time, nuclear power only accounts for a small amount of the electricity generated in the U.S.

The largest known uranium reserves are in the U.S., Canada, and South Africa, other significant reserves are in France, Spain, Sweden and Australia. The USSR is believed to have major uranium deposits. The U.S., with 35 percent of the estimated free world uranium reserves, has an estimated 370,000 short tons that could be mined at under $10 per pound. The annual domestic uranium demand for the year 2000 is estimated to be between 61,000 and 69,000 short tons compared with 2,700 in 1968.

It is the position of the current administration to defer a U.S. comitment to advanced plutonium based nuclear technology, including an indefinite deferment of commercial reprocessing and recycling of plutonium; however, the national energy plan places heavy reliance on uranium-based nuclear electrical generation. This includes an expansion of uranium enrichment capacity. The administration energy plan predicts an increase in electricity produced by nuclear energy from 1976 to 1985 of 3.6 to 3.8 times above what is presently produced. The U.S. Forcast for uranium prices is for a 65 percent increase between 1976 and 1985 (Engineering and Mining Journal, 1977).

Although uranium is widespread, mineable concentrations are not. The principal domestic resources occur as masses in continental and marginal marine sandstone and associated rocks and are numerous in some western states. Most geologists think that the uranium in these deposits was derived by leaching from volcanic glass in or overlying the host rock, or from granitic terrains along the margins of sedimentary basins. The host rock of uranium ore is usually sandstone. Deposits of this type occur in New Mexico, Colorado, Wyoming, and the Texas coastal plain. Vein deposits of uranium may occur as fissure fillings in fault, joints and fracture zones of many kinds of rocks. Vein deposits are throught to have been deposited from hydrothermal solutions. Some phosphate rocks such as the Permian Phosphoria Formation in Idaho, Montana, Utah, and Wyoming contain small percentages of uranium, as do lignites of eastern Montana (USGS, 1973).

In Montana, uranium was first discovered in the 1950's near Clancy and Boulder, Jefferson County. The deposits occur in quartz monzonite, granodiorite, and related rocks of the Boulder batholith. In these areas, the uranium is associated with vein zones which also contain, in places, lead, silver, zinc and copper. From this area, a few hundred tons of ore have been produced and no current mining is taking place.

Other uranium deposits in the Statewide 208 area are located near Saltese in Mineral County, in Ravalli County, in Beaverhead County, in the lignite deposits of eastern Montana, in the shale and lignite beds of Lewis and Clark, Broadwater and Jefferson Counties, and in the bedded phosphorite deposits of southwestern Montana.

The USGS (1968) states:

> If the need were great enough, very large quantities of uranium could be recovered from the uraniferous lignite deposits of eastern Montana and from the phosphorite deposits of western Montana. Montana therefore is an important potential source for the future production of uranium.

There are existing uranium leases in 14 Montana counties, ten of which are in the Statewide 208 Area (Table 9). Prospecting is currently underway in fifteen counties, ten of which are in the Statewide 208 Area (Table 10). Although prospecting and leasing in Montana are active, no commercial deposits have been announced. The most promising deposits, in Carter County, are outside the Statewide 208 Area. It appears that near future (next 10 - 15 years) possibilities for development of underground or open-pit uranium in the Statewide 208 Area are poor, and solution mining will depend on discoveries of commerical deposits. Water quality impacts of uranium development are discussed in Chapter XI .

TABLE 9

Existing Uranium Leases in Montana as of November 1, 1977

COUNTY	ACRES	COMPANY
BEAVERHEAD	7107	Lucky Mc Uranium Corp.
	440	E. O. Larson
BLAINE	840	Pioneer Nuclear, Inc., etal
CARTER	1920	Montana Nuclear Corp.
	1252	Exxon Corp.
	6728	Kerr McGee Corp.
	640	Frontier Res., Inc.
	800	Mobile Oil Corp.
	1600	Felmont Oil Corp.
	960	Homestake Mining Co.
CHOUTEAU	120	Wyoming Mineral Corp.
FALLON	480	Felmont Oil Corp.
GALLATIN	2080	Lucky Mc Uranium Corp.
HILL	1880	Pioneer Nuclear, Inc., etal.
JEFFERSON	7126	Lucky Mc Uranium
JUDITH BASIN	400	Continental Oil Co.
LEWIS & CLARK	1120	St. Joe American Corp.
McCONE	640	Wyoming Mineral Corp.
MEAGHER	2560	Lucky Mc Uranium
STILLWATER	9120	Sabine Production Co.
SWEETGRASS	320	Sabine Production Co.
TOTAL	48,133	

Source: Montana Department of State Lands
Through the Montana Energy Office

TABLE 10

Active Uranium Prospecting Permits in Montana, as of June 1, 1977

Permittee	County
Anschutz	Carbon
Bur West	Carbon
Bureau of Mines	Missoula and Ravalli
Cominco American Incorporated	Carbon
Continental Oil Company	Jefferson and Mineral
Exxon Company, U.S.A.	Broadwater, Carbon, and Carter
Felmont Oil Corporation	Carter and Fallon
Frontier Resources	Carter
Gulf Mineral Resources Company	Musselshell
Kerr-McGee Corporation	Carter
Mobil Oil Corporation	Carter
NRG	Powder River
Pioneer Nuclear	Carter and Madison
Sabine	Stillwater
Wyoming Mineral Corporation	Fergus, Judith Basin, and McCone

Source: Montana Department of State Lands.
Through the Montana Energy Office

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MINING AND WATER QUALITY

Mining and environmental alteration are synonomous. The magnitude of environmental disturbance is principally a function of the type of excavation, the nature of local topography and geology, and the size of the proposed operation. The significance of the environmental disturbance is principally a function of the type of mineral mined, type of waste rock, sensitivity of the operator to environmental problems, regulatory requirements, and the nature of the surrounding environment, particularly the relationship to surface water and groundwater.

Major ways in which mining activities impact water quality are:

1. Toxic, acid, or alkaline drainge from mines, wastes, and tailings
2. Erosion and sedimentation
3. Accidents

MINE DRAINAGE

The first category includes acid mine drainage and alkaline mine drainage. The type and characteristics of drainage produced at a particular mine or mined area will depend on the mineral mined and the geochemisty of the surrounding rocks. Acid mine drainage is generally defined as having a low pH, net acidity, high iron, high sulfates, and significant concentrations of aluminum, calcium, magnesium, and manganese. Alkaline mine drainage has a pH at or above neutral, net alkalinity, high sulfates, low aluminum, and significant concentrations of calcium, magnesium, and manganese (Scott and Hays, 1975).

Mine drainage problems can also arise from simple dissolution of minerals. Many substances including fluorospar, gypsum, limestone, uranium, apatite, and other minerals are soluble to some extent in water. If water soluble minerals are allowed to contact surface water or groundwater, it is possible for small to large amounts of material to enter into solution, then move with the water to points of discharge. Mining by its very nature typcially exposes earth materials rich in a specific mineral commodity and, as a result, often exposes these minerals to the dissolving effects of surface or groundwaters. Some exposed materials, such as arsenid, may be dissolved and can become present in toxic amounts in water, however, at other mines, minerals such as limestone might be exposed which, when dissolved, yield calcium which makes water hard but which does not have a toxic affect.

Acid Mine Drainage

A great deal of effort has been employed to understand and control acid mine drainage. Coal mine drainage is probably the largest contributor to this problem, polluting an estimated 10,000 miles of streams in the eastern United States (Appalachian Regional Commission, 1969). Acid drainage of this type occurs also in Montana in the Belt, Stockett and Sand Coulee areas near Great Falls. A number of inactive base metal mines contribute acid drainage as well, causing problems in streams such as Silver Bow Creek, Dry Fork of Belt Creek, and streams near Jefferson City, Lincoln, Philipsburg, and Red Lodge. Acid drainage is the major and most important contributor of chemical stream pollution by mining activities in Montana.

The dissolution of toxic metals such as zinc, lead, copper, and cadmium is greatly accelerated when the pH of the solution passing over the mineral is lowered. The relationship between pH and solubility of several metals in acid mine drainage is shown in Figure 6. The solubility or stability of these metals is also a function of temperature, concentration of other dissolved ions, and the oxidation reduction potential of the solution (Martin and Mills, 1976). The potential for metal liberation i probably greatest where acid is formed in the absence of calcareous formations, which tend to add alkalinity and buffer the water.

There are a number of technical alternatives available for preventing, abating, and reducing the amount of acid produced by mine waters (Martin and Mills, 1976; McArthur, 1970; Montana DNRC, unpub.; EPA, 1973). Prevention techniques include avoiding mining pyrite, or related sulfide deposits, dewatering of adjacent aquifers, grouting, mining in a down-dip direction, and judicious placement and reclamation of mine spoils. necessary factors in acid drainage are: (1) a fairly soluble form of sulfide, (2) oxygen, and (3) moisture. Take away any one of these elements and the production of acid is reduced or eliminated. The most obvious prevention technique is to avoid mineral deposits associated with pyrites. However, if the mineral deposit is of sufficient economic promise, other alternatives can be used to prevent water quality problems and to provide compliance with discharge restrictions. If water is encountered while driving an adit or shaft, acid production can be prevented or abated by grouting inflows or removal of groundwater before it encounters pyrite minerals. Water control has been a technique long practiced in the mining industry. In some cases, unexpected water flows are encountered, such

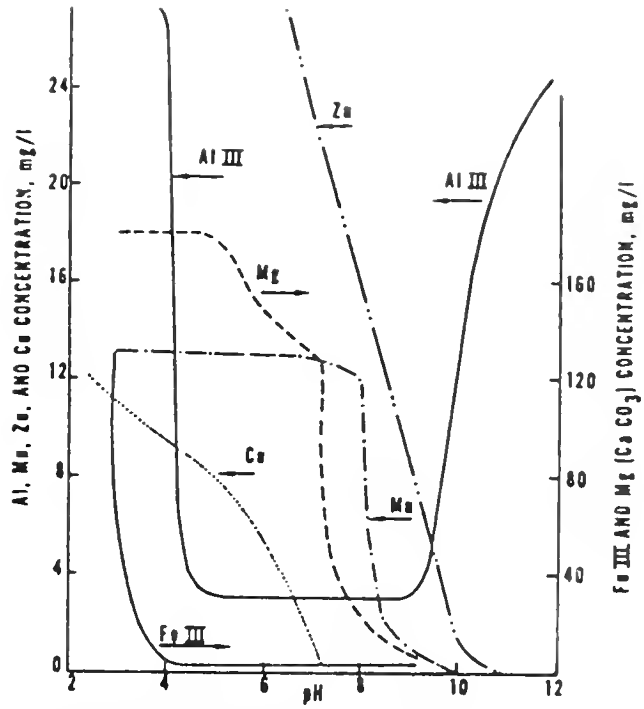

Fig. 6—Solubility of Al, Mn, Fe III, and Mg in acid mine drainage at various pH's.

(Hill and Wilmoth, 1977)

as occurred in Johns-Manville Corp. exploration activity near the West Fork Stillwater River, Sweetgrass County. The feasibility of any prevention or abatement alternatives is specific to each mining situation.

Once ore is removed and mine waste stockpiled, it is again necessary to eliminate the contact of water, air and sulfide minerals. Adequate drainage of surface runoff is necessary as well as elimination of the seepage of precipitation into waste dumps. This may require an artificial seal of bentonite, plastic or other impermeable covering to protect sulfide-bearing waste piles from contact with water. Adequate topsoil and vegetation sufficient to evapotranspire the entire amount of precipitation is a viable alternative at some waste disposal sites. Another alternative in drainage control management is to allow acid production, but control it prior to reaching streams or groundwater systems. This is difficult to accomplish for long periods of time, or for large volumes of water, and requires hydrologic monitoring and provisions for control and reclamation when the mine ceases operation.

Treatment of acid water to reduce its impact on receiving streams is a viable alternative in some cases. Potential methods of treatment are; forced evaporation, reverse osmosis, electrodialysis, ion exchange forced freezing, controlled release dams, chemical neutralization, or aeration and settling. Depending on the quantity of water to be treated, all of these alternatives with the possible exception of the last two, require significant capital investment in treatment plants, continuous operation, and disposal of sludge or brine. Except in unusual cases, these methods are not cost effective for known problems in Montana. Funds could be more productively spent in other areas of pollution control.

Drainage from fourteen large inactive mining areas in Montana affect the water quality of about 160 kilometers of streams (Martin and Mills, 1972). Most of these water quality problems are caused by acid mine drainage and high concentrations of heavy metals, although, some sediment problems have been created.

Several of these inactive mine areas have undergone detailed investigation, especially the Hughesville-Barker, McClaren, and Sand Coulee areas. At Hughesville, a cooperative program among Department of Natural Resources and Conservation, the Water Quality Bureau, and the Environmental Protection Agency has outlined a corrective program to abate the degradation of Galena Creek, and the Dry Fork of Belt Creek (Montana DNRC, 1978).

This technical investigation indicated that seepage of precipitation into mine waste dumps could be reduced by resurfacing wastes with topsoil and revegetating them. This treatment has been completed and effects on the stream are being evaluated.

The McClaren Mine and mill tailings located near Cooke City discharge large concentrations of metals and acid into Soda Butte Creek, Daisy Creek, and the Stillwater River. Rerouting Soda Butte Creek and regrading the tailings has lowered the level of pollution in that drainage, although not enough to support life for a three kilometer reach (Martin and Mills, 1976). The mines and related dumps have not been altered and continue to contribute metals and acidity that adversely impact the stream. The Fish and Game Department, Water Quality Bureau, and Department of Natural Resources and Conservation have studied this area to determine the most practical method of treatment (Montana DNRC, unpub.)

The Comet Mine affects six kilometers of High Ore Creek in Jefferson County. This reach is sterile because of high metals concentrations and has a degrading impact in the Boulder River. The Fish and Game Department and the Department of Health and Environmental Sciences are studying the possibility of using surplus excavated material from the future construction of I-15 between Boulder and Butte to dam High Ore Creek and submerge the tailings. It is expected that once the tailings are covered with water and deposited organic matter, the oxidation of pyrites in the tailings will be halted (Martin and Mills, 1976).

The nature of acid mine drainage development is basically understood. A critical factor in acid production is iron disulfide (FeS_2), in the relatively soluble crystalline forms of pyrite and marcasite. Other base metal sulfides may contribute smaller amounts of acid. These minerals are present in varying amounts in many metal ores and coal bodies. In high-sulfur eastern coals, pyrite is generally the principal contributor to the total percentage of sulfur. Mining exposes sulfides to the atmosphere and moisture, either in mine shafts, spoil piles, or tailings, causing them to decompose. This decomposition takes place in a series of reactions, some of which are not completely understood. The overall result is:

$$2\ FeS_2 + 2\ H_2O + 7O_2 \rightarrow 2\ FeSO_4 + 2\ H_2SO_4$$

Pyrite + Moisture + Oxygen → Ferrous Sulfate + Sulfuric Acid

A number of further reactions, both chemical and biological, accelerate acid production, and the eventual formation of an orange-colored precipitate ferric hydroxide ($Fe(OH)_3$) (McArthur, 1970).

Aeration and settling occur naturally in all streams, at different rates, depending on stream characteristics. Neutralization also occurs naturally with dilution by streams of higher pH and by flows contacting calcareous materials such as limestone and dolomite. These natural processes can be enhanced by addition of limestone rock to streambeds or mine shafts to prevent the development of acidic water. Pressurizing mines with an inert gas can be used to prevent the formation of acid. Mine backfilling may eliminate oxygen contact with minerals and dispose of mine wastes and tailings. Any system used would require maintenance, monitoring, and periodic evaluation of the nature of environmental impact. Thus, acid mine drainage must be considered in the development of a mine, during its operation, and its reclamation program.

In Montana, effluent from active mines are subject to the Montana Pollutant Discharge Elimination System (MPDES), which requires use of best practicable control technology (BPCT) currently available, by July 1, 1977. Limitations placed on the concentrations of pollutants contributed by mine drainage have been proposed by EPA and subsequently suspended pending further evaluation of the technological and economical ability of the mining industry to control such effluents. In effect, there are presently no BPCT's applicable to mine water effluents, except from sand, gravel, crushed rock, and phosphate mines (Dick Montgomery, pers. comm.). There are no known acid drainage problems related to mining activities of these commodities, nor is there significant possibility that any will develop.

If a new mining activity is allowed to discharge by the Water Quality Bureau, the discharge may be required to cause no degradation to the receiving stream. This evaluation is pursuant to the so called "non-degradation statement" in Montana Laws Regarding Water Pollution (Section 69-4808-2). Degradation has been interpreted in the past as a measurable change in the biological ecosystem supported by a particular stream, or a measurable increase in toxic or harmful constituents. With this interpretation, Montana Water Quality Standards could well be more stringent than the best available technology economically achievable (BAT) limitations and new source performance standards (NSPS), when these are promulgated by the EPA. The original date scheduled for application of BAT was July 1, 1983. If a bill now before Congress is passed, the deadline will be delayed one year until mid 1984 (Dick Montgomery, pers. comm.).

It is critical to anticipate the future development of acid mine drainage. Once an operator abandons a mine, correction of problems becomes significantly more difficult and more expensive. It is difficult today to find owners of some old mines with acid discharges. It is also more difficult and costly to correct the problem.

If old mines are reactivated, existing problems may be corrected. For example, the Crystal Mine, Jefferson County, long a contributor of metals to Cataract Creek and the Boulder River, may be purchased by a large mining company, which has proposed clearing up the old problems. The present owner has been unwilling or unable to do so (D. Peterson, pers. comm.). Thus, the activation of old mining properties may lead to elimination of certain past problems.

Choosing the best alternative for preventing, abating or eliminating acid mine drainage is site specific. As market conditions and technologies change, new pollution control methods may become applicable or old ones feasible. Fisheries might be determined to be valuable enough to allocate public funds for correcting old problems. Acid mine drainage is a damaging and long-lived problem and must be considered as a major problem in any new mining.

Non-acid Mine Drainage

Some mines have discharges that are not acidic. These discharges, however, still contain toxic concentrations of metals and other pollutants. Mine drainage with a pH greater than six is considered to be non-acid (Scott and Hays, 1975). These type waters generally do not have as severe problems as those associated with acid drainage.

A common pollutant to mining is nitrate due to blasting. If a mine has any type of discharge, nitrates, a macronutrient in most aquatic systems, will be dissolved and carried to receiving streams or seep underground. This is a problem as long as a mine is active and for a relatively short time after becoming inactive.

Other pollutants are specific to ore bodies being mined and chemical and physical conditions in the mine. Phosphate is a soluble macronutrient and mining of phosphate ore may cause streams to be degraded by its addition. Combined with nitrates in the mine drainage, undesirable aquatic growth and algae blooms can occur. Gypsum and fluoride are two non-metallic substances that can cause problems simply because they are soluble. Runoff or groundwater seepage from gypsum deposits contribute hardness and some salinity which can be detrimental to aquatic ecosystems. Fluoride produced in flouospar mines can become a health problem when concentrations exceed established

standards. Arsenic, copper, and zinc are soluble in significant concentrations in the pH range between six and eight, but solubility drops sharply as the pH increases above eight. Aluminum and uranium solubility increases sharply as the pH increases above nine. Any of these metals can cause problems in receiving waters. Discharges from asbestos mines are likely to contain that mineral in suspension.

Problems related to non-acid mine drainage are a function of the impacts of nutrients, metals, and salts on hydrologic systems. In the pH ranges of six to nine, chemical dissolution of exposed material is limited and the solubilities of most metals is low. Many times mine waters create more problems for the mine operator than for the receiving streams. However, non-acid discharges from mines have the potential of causing small but long-term degradation of ground and surface waters.

Technological solutions available for prevention, correction, and abatement of mine discharges and problems resulting from those discharges are similar to those previously described.

The key issue with respect to non-acid mine drainage is prevention of future problems. Existing non-acid mine discharges have not caused significant problems in Montana. The Montana Pollutant Discharge Elimination System provide regulatory control of mine discharges if there is an existing owner or operator. Future mining operations will be covered by this system and if problems can be anticipated, they can largely be controlled.

EROSION AND SEDIMENTATION

Erosion and sedimentation problems are caused by a number of activities. Road building, erosion of waste dumps, tailings, reclamation areas, and facilities areas, channel relocations, and placer mining all can cause

increases in sediment loads to streams. Roads, drill sites, waste dumps, exploration cuts, sites prepared for facilities all require earth disturbing activities. These activities normally result in increased potential for erosion creating problems of suspended sediment and turbidity in nearby surface waters. Proper siting, design, construction, and operation of roads, waste dumps, and mine facilities can be very important in preventing or minimizing problems due to earth disturbances and erosion. In almost all mining developments, some potential for erosion is generally present during the life of the mine particularly during exploration and development phases. Consequences of such erosion greatly depend upon location of mining with respect to streams, runoff expected from the mine, and control facilities such as settling ponds present at the mine.

The success of reclamation of mined areas is the most important factor determining long-term impacts of erosion and sedimentation to streams. If vegetation is able to re-establish itself, and if soil erosion rates become similar to those of surrounding undisturbed areas, then the streams of an area will not suffer degradation. However, unsuccessful revegetation, accelerated rates of erosion, initiation of mass movement, and increased runoff rates all can contribute to stream instability. It is critical that reclamation success be carefully monitored so that corrections can be undertaken while a mine operator is still available to conduct the work.

ACCIDENTS

Accidents are an inevitable part of any complex activity, such as a mining operation. Accidents vary in magnitude, frequency, and significance. In any mining activity, there is a probability that drilling mud might

spill into a stream, that an ore truck might skid off an icy road, that a pipeline might leak, or that equipment malfunctions might occur. Obviously, there is a different probability for each type of accident, but it is important to realize that each event has a probability. Given the number of mining activities in Montana, it is not surprising that unforeseen events have occurred - that settling ponds have failed, that unexpected water flows have been encountered, that tailings dams have washed out. Mining in any drainage creates numerous potential problems that have a finite probability of occurrence.

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PROBLEM IDENTIFICATION AND COST EVALUATION

SPECIFIC PROBLEM IDENTIFICATION

Method of Investigation

During summer and fall, 1977, interviews were conducted with many individuals in Montana regarding the location and nature of specific mining operations and their impacts on water quality. Contact was made with every U.S. Forest Service District Ranger Station in the Statewide 208 Area, as well as other specialists of the Forest Service, Bureau of Land Management, Montana Fish and Game Department, Water Quality Bureau and Reclamation Division. Over sixty individuals or groups were contacted. A full list of all individuals contacted is included in Appendix B . These individuals answered numerous questions related to the extent of mining activities and problem sites in their areas. Appendix C contains a copy of the questionnaire used in the inventory.

Time permitted only a brief field review of some suspected field problems. In many cases, observations about water quality problems were subjective, and no field data was available to quantify problems. No more than twenty-five percent of cited problems have supporting field data. In many cases, however, the physical evidence of mine drainage or stream disruption was cited as being obvious.

Identification of Problem Sites

Table 11 lists all site specific problems identified in this investigation (Figure 7 for location). It is clear that mining related water quality problems have occurred in nearly every major drainage basin in central and western Montana. Fifty-seven problem sites or mine drainages of unknown

TABLE 11

WATER QUALITY PROBLEMS, IMPACTS AND SOLUTIONS RELATED TO MINING

Hard Rock Mining

	Drainage Basin Code	County	Mining District/ or mine operator *	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
1	40EJ	Phillips	Ruby Gulch Group I	25N25E7,18	Ruby Creek/ Missouri Rv.	Tailings washed into stream		
2	40EJ	Phillips	Gold Bug Mine I	25N24E22	Montana Gulch/ Rock Ck./ Missouri Rv.	Acid mine drainage problems		
3.	40I	Phillips	Little Ben Mine I	25N24E15D	King Ck./ Peoples Ck./ Milk River	Tailings washed into stream		
4.	41D	Beaver-head	Tomatan/ Mine O	2S17W15	Placer Ck./ Trail Ck./ North Fk. Big Hole Rv.	Developed access road up stream bed to get to expl. adit; construction has undercut slope		
5.	41D	Beaver-head	Elkhorn I	4S12W11,14	Elkhorn Ck./ Wise Rv./ Big Hole Rv.	Old adit discharges acid waters to ck		USFS planning a settling pond line with limestone
6.	41D	Madison	Rochester Mining District I	3S7W5,6,7,8 2S7W31,32	Rochester Ck./ Big Hole Rv.	Extensive old mining; dumps have high amounts sulfide minerals; dumps erode into stream in spring	Channel has precip-itate	
7.	41E	Jeffer-son	Crystal O	7N5W19,20	Uncle Sam Gulch/ Cataract Ck./Boulder Rv.	Creek runs through pit and transports area waste	High turbidity &metals content in stream pollutes Boulder Rv. Fe,Zn,Cu,Pb,Cd, As	Need settling pond and treatment of high metals in water

* O Operating
I Inactive
A Abandoned

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
8.	41E	Jefferson	Comet I	7N5W36	High Ore Ck./ Boulder Rv.	Tailings disposed in Creek	High turbidity & metals in Ck. Fe, Zn,Cu,Pb,Cd,As pollutes Boulder Rv. during high stream flow, tailings & metals pollution may occur to Jefferson Rv.	Divert stream around tailings or remove tailin
9.	41E	Jefferson	Elkhorn Queen I	6N3W26	Elkhorn Ck./ Boulder Rv./ Jefferson Rv./	Runoff from dumps and tailings; looks bad for ½ mile from mine		
10.	41G	Madison	Mammoth A	2S3W18	South Boulder River/Jefferson River	Runoff from precipitation washes tailings into creek; ore minerals auriferous pyrite & chalcopyrite, sphalerite	¼ mile downstream, high sediment loads; quality unknown	
11.	41I	Broadwater	Argo I	11N1E27	Hellgate Gulch/ Canyon Ferry Lake	Some acid drainage; some dump erosion	Small impact	
12.	41I	Broadwater	Klein-Schmidt I January I E. Pacific O	7N1W3 8N1W26 8N1W26,27	Weasel Ck./ Beaver Ck./ Canyon Ferry Lake	Acid mine drainage	Stream affected downstream to Beaver Ck.	
13.	41Q	Cascade	Neihart Mining District A	14N8E 27, 28,29,30, 31,32,33	Carpenter Ck./ Belt Ck./ Missouri Rv.	Old tailings ponds and dumps are actively eroding into ck.	Belt Creek "ran -red: 1975 summer from Carpenter Creek	Haul in topsoil seed old onds; stop erosion

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
14	41Q	Cascade	Silver Dyke A	14N8E10	Carpenter Ck./ Belt Ck./ Missouri Rv.	15-20 gpm discharge into creek	Belt Creek "ran red" 1975 summer from Carpenter Ck.	
15	41Q	Judith Basin	Block P A	14N9E6,7	Dry Fork/ Belt Ck./ Missouri Rv.	Discharge - seepage from waste dump	Pb,Fe,Mg,Zn	
16	41QJ	Lewis & Clark	Gould Mine A	13N7W10	Gould Ck. & Fool Hen Ck./ Virginia Ck./ Canyon Ck./ Little Prickly Pear Ck./ Missouri River	Acid mine drainage and waste dump erosion		
17	43B	Park	Jardine A	9S9E4,9, 10	Bear Ck./ Yellowstone Rv.	Tailings have slumped into creek	Sedimentation problems; As,Hg and heavy metals	Revegetation of some tailings planned; bank stabilization needed
18	43C	Park	McLaren I	9S14E10,11	Daisy Creek/ Stillwater Rv.	"Ponding of snowmelt and rainfall waters in disturbed areas, resulting in runoff and groundwater emerging with high, heavy metal concentrations."	Daisy Ck., 1.8 miles downstream of mine, void of fish, and bioassays resulted in 100% mortality of trout in 24 hours iron precipitate covers channel bottom	Bury high sulfide materials; cover material and reveg tate; constructio of drainage ditche around disturbanc would decrease metal load to Daisy Ck. by 7 estimated cost $292,000

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
19	43D	Park	Glengary I	9S14E2,11	Fisher Ck./ Clark Fork of Yellowstone	Infiltration into mine from two raises and groundwater seeps; ponding of snowmelt and rainfall waters which then pass through disturbed material; result in discharges of high acidity, high in sulfate, iron, and aluminum	Iron precipitate covers channel bottom	Regrade, revegetate Lulu Pass area; seal raises and portals; would decrease metal loads in Fisher Creek by at least 79% estimated cost at least $120,000
20	76C	Lincoln	A	25N30W17A	Silver Butte Creek/East Fisher Creek/Fisher Rv.	Discharge from adit for 40 yrs.; seeps into ground prior to reaching creek		
21	76D	Lincoln	Snowshoe A	28N32W11	Snowshoe Ck./ Big Cherry Ck./ Libby Ck.		High lead concentrations in stream; zinc from tailings leaching into stream	
22	76E	Granite	A	10N16W20	Brewster Ck./ Rock Ck./	Shaft with discharge immediately next to the creek		

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
23	76F	Lewis & Clark	Mike Horse/ Heddelston District I	15N6W28		Acid mine drainage; tailings dam burst depositing tailings in ck.; necessitated excavations in ck. for gravel to rebuild dam		Tailings dam has been repaired
24	76F	Lewis & Clark	Sevenup Pete A	14N7W20,29	Sevenup Pete Ck./Blackfoot River	Erosion of waste dumps	High siltation, mineral acid problems	
25	76G	Deer-Lodge	Cable Mine A	5N13W10	Cable Ck./ Warm Springs Clark Fork	Tailings are quicksand swampy below dumps; Mg staining on mill dumps		
26	76G	Deer-Lodge		5N8W7,8	South Fork Dry Cottonwood Ck./ Clark Fork	Adit mine discharge; quality unknown		
27	76G	Deer-Lodge	Champion	6N8W28,33	Orofino Ck./ Clark Fork	Adit has discharge into creek	Impacts not known	
28	76G	Granite	Hidden Lake	6N13W35	Warm Springs Creek/Clark Fork	Adit has discharge; no water quality data; ore minerals - pyritic quartz vein		
29	76G	Granite	Forest Rose A	9N12W22	Dunkelberg Ck./ Clark Fork	Acid mine drainage; erosion of tailings; culvert under tailings plugged; major flood will wash out tailings; ore minerals - argentiferous galena, sphalerite, pyrite, angeloite, cerussite, smithsonite	No sampling conducted to date	

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
30	76G	Powell	A	7N8W10,11	Rocker Gulch/ Cottonwood Ck./ Clark Fork	Mine discharge of unknown quality	Possible arsenic in stream	
31	76G	Powell	Master I	8N12W12	Gold Ck./ Clark Fork		Possible arsenic in stream	
32	76G	Silver Bow	Butte Highlands 0	1N7W31	Basin Ck./ Silver Bow Creek	Old adit discharges to stream; ore - auriferous pyrite & pyrhatite, galena, sphalerite, chalcopyrite	No data available but Basin Creek Reservoir part of Butte city water supply	
33	76G	Silver Bow	Berkeley Pit/Butte Underground Mines 0	3N7W5-8, 17,18 3N8W1,2, 11,15	Silver Bow Ck./ Clark Fork	Anaconda effluent main source of flow in Silver Bow Ck.; old mill tailings also erode into creek	Silver Bow Crrek has high pH and some metals downstream to Warm Springs ponds (26 miles)	
34	76GJ	Granite	Wasa A	9N12W27	Douglas Ck./ Flint Ck.	Acid mine drainage; ore minerals - sphalerite, pyrite, chalcopyrite		
35	76GJ	Granite	Phillipsburg Mining District	7N14W	Flint Ck./ Clark Fork	Tailings erosion, adit discharges	High mercury levels in Flint Creek	

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
36	76M	Mineral	Nancy Lee O	17N26W5,6 18N26W31	Keystone Ck.	Tailings piled near dry channel; apparently acidic discharge from old adit but does not reach a perennial stream	No data available	
37	76M	Mineral	Tarbox A	20N31W35,36	Packer Ck./ St. Regis Rv./ Clark Fork	Stream runs through old waste dumps		
38	76M	Mineral	Bud King Missoula O	18N26W35	Pardee Ck./ Clark Fork	Discharge from old adit may reach creek		
39	76M	Missoula	A	16N23WB	Kennedy Ck./ Ninemile Ck./ Clark Fork	Old adit discharge to ck.		
40	76M	Missoula	Joe Wallit, Missoula A	17N24W8	St. Louis Ck./ Ninemile Creek	Stream erodes waste pile; stream blocked at times	No data but "green water" may imply problem	
41	76N	Sanders	Holliday I	26N34W25,36	West Fork Pilgrim Ck.	Stream runs through tailings dump		
42	76N	Sanders	Jack Waite I	22N32W17C	Dixie Ck./ Beaver Ck.	Waste from old workings in and alongside creek; ore minerals - galena, sphalerite, tetrahedrite, pyrite, chalcopyrite	No data available	

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
43	76N	Sanders	Heidel-berg A	27N31W29,32	East Fork Rock Creek	Old adit discharges to stream		
44	76N	Sanders	State Mining Co.	20N28W14,23	Eddy Creek	Waste debris in creek; discharge from adit into creek	No data available	

Mills

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
45	41B	Beaver-head	Gold Leaf A	8S11W8B	Grasshopper Creek/ Beaverhead Rv.	Creek has eroded into tailings pond; opposite bank of over-size gravel from hydraulic mining eroding; runoff across tailings carrying tailings into creek	Tailings sediments are main source of heavy metals contamination in creek and Beaverhead Rv. sedimentation problems from eroding banks metals' levels threaten aquatic life downstream	Bank stabili tion and di sion of surf runoff; coul reduce tota metal loads 80 %
46	41B	Beaver-head		6S10W	Rattlesnake Ck./ Beaverhead Rv.	Sediment from mill tailings		
47	41D	Beaver-head	Mining & Minerals Resource Corp. I	3S11W1D	Sappington Ck./ Trapper Ck./ Big Hole Rv.	In 12/75 dike of tailings burst 30-50 tons of tailings exited a portion into creek and into Trapper Ck.	Depositing of sandy materials	Has been cle up
48	41QJ	Lewis & Clark	Gould A	13N7W 14,15	Fool Hen Creek Virginia Creek Canyon Creek Little Prickly Pear Creek	Mill tailings washed by acid mine drainage	Sterilize creek downstream of tailings	
49	76GJ	Granite	Old Red Mill A	7N14W 36ABD	Douglas Creek/ Flint Creek		Sediment & metals problem	
49a	43B	Park	McLaren Mill A	9S14W	Soda Butte Ck./ Lamar Rv./ Yellowstone Rv.	Erosion of tailings into creek	Stream impacted for twelve miles; high iron and sulfate	DNRC stu

	Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
49b	76GJ	Granite	A	8N13W	Boulder Ck./ Flint Ck.	Eroding tailings	suspected problems	F & G will monitor
50	76F	Lewis & Clark	A	14N9W28	Blackfoot Rv.	Acid mine tailings erode into stream		

Gold (Cyanide Leach)

ainage asin ode	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions	
41I	Lewis & Clark	John B. White leach mill I	12N5W34CC	Silver Creek/ Missouri Riv.	2/77 (?) leaks in holding ponds; road build across creek, no culvert	Fish kill for 4 miles below mill; streamflow blocked	Under compliance order from DHES; cannot reopen until ponds fixed	52
41B	Beaver-head	Hendrich Mine	8S11W 7	Grasshopper Creek/Beaver-head River	Runoff into creek from tailings pond			51
41B	Beaver-head	Ermont A	6S11W35	Ermont Gulch/ Beaverhead River	Runoff from cyanide leach dumps	Unknown; gulch is ephemeral		51A
41C	Madison	Virginia City/ Sheitland O	6S3W26	Alder Gulch/ Ruby River	Tailings pond in valley bottom; potential prob-lem if large flooding			51B

Coal

Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions	
41QJ	Cascade	Sand Coulee Mining Area A	19N4W31,36	Sand Coulee Creek/Missouri River	9 old mines discharging acid waters	About 25 miles show yellow deposit or suspension, show effects of AMD; reaches Missouri	Detailed study suggests treatment but insufficient funds available	53

Fluorspar

Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions	
76M	Mineral	Snowbird O	12N25W19	Cedar Log Creek/Fish Creek/Clark Fork	Discharge from operations reaches creek			54

Gems

Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions	
41S	Judith Basin	Yogo Sapphire O	13N11E21	Yogo Creek/ Judith Riv.	Tailings pond could be washed out by flood; washing operation may go into creek	High sediment loads in creek	Move tailings pond, but alternative location difficult to find	55

Graphite

Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions	
41I	Broad-water	National Minerals Corp. O	7N1E29,32	Indian Creek/ Missouri Riv.	Water discharging from adit and may flow into Indian Creek at high flow	No quality data		56

Gypsum

Drainage Basin Code	County	Operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
41S	Fergus	Shoemaker Mine/U.S. Gypsum O	14N19E12	Big Springs Creek/Judith River/Missouri River	Waste dump erosion	Sediment problems in stream	WQB abatement order 9/24/75 No DSL jurisdiction 57

Limestone

Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions	
41I	Jefferson	Montana City Quarry/ Kaiser O	9N2W12,13	Prickly Pear Creek	Waste dump slumped into Prickly Pear Creek	Resulted in high pH in creek; fish kill	New containment berm; topsoiled and revegetated dump no longer used	58

Phosphate

Drainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
76G	Powell	Brock (Anderson)/ Cominco Amer. O	10N9W19	Brock Creek/ Clark Fork River	Mine yard and crusher in stream bed		

59

rainage Basin Code	County	Mining District/ or mine operator	Location	Drainage	Source of Water Quality Problem	Water Quality Impacts	Solutions
				Quartz			
41E	Jefferson	Basin Quartz Quarry/ Pacific Silica O	6N5W16	Boulder River	Discharge sediment from settling ponds (1974) WQB report on inadequacies of mine site for controlling erosion into creek	Sediment in creek	Collect runoff ·63 from mine site dike around process area; stabilize road cuts
				Vermiculite			
76D	Lincoln	Vermiculite Mtn. Mine/ W.R. Grace O	31N30W10, 14,15,21-23,26-28	Rainy Ck./ Kootenai Rv.	Old tailings deposited in Creek; Erosion at mine area may cause problems	Sedimentation and occasional high sediment loads	Detailed study of 6- mine

Sand and Gravel Mining

	Drainage Basin Code	County	Operator	Location	Stream Affected	Mining Activity and Problem
101	41E	Jefferson	Montana Dept. of Highways O	1N3W3CC	Boulder River	Mining terrace of Boulder River close to river, stream capture of mined area likely since MDH has not put in promised rip rap
102	41G	Jefferson	Continental Concrete Co. O	1N4W1C,2D	Jefferson River	Mining terrace of Jefferson River; dewaters pit by discharging to river; may be stream capture
103	40J	Hill	Hill County A	29N16E16BD	Beaver Creek/ Milk River	Former pit on terrace of Beaver Creek; stream has captured pit; gravel berms have been ineffective
104	41K	Cascade	Big Sky Sand and Gravel O	21N1W36C	Sun River	Mining streambed of Sun River, wash plant on terrace may discharge to river
105	41K	Cascade	Lewis Construction Co. O	21N1E32DD,29	Sun River	Mining streambed of Sun River, wash plant on terrace may discharge to river
106	41O	Teton	? O	24N5WC	Teton River	"Extraction of gravel in stream channel has aggravated lateral erosion and caused widening of flood channel. Depletion of bedload on property has caused subsequent post-flood headcutting, scouring, erosion
107	41O	Choteau	Charles J. Naeseth A	24N8E16B	Teton River	Mining streambed of Teton River; dumps excess concrete into river/ has agreed to move
108	41S	Fergus	McDonald Ready Mix O	15N18E11C	Boyd Creek/ Big Spring Creek/ Judith River	Settling pond overflow may impact stream
109	42M	Dawson	Dawson County O	18N55EAA	Morgan Creek	Mining streambed of creek
110	42M	Dawson	Fisher Sand and Gravel O	16N54E27	Sevenmile Creek/ Yellowstone	Mining activity, stockpiles, disturbance in channel and floodplain of Sevenmile Creek
111	42M	Dawson	Dawson County O	16N53E13CC	Sevenmile Creek/ Yellowstone	Mining streambed of creek

112	42M	Richland	Sidney Ready Mix O	23N59E32BC	Lone Tree Creek/ Yellowstone	Settling pond "has potential and probably has overflow into creek"
113	43B	Park	Eggar Const. O	2S9E2	Yellowstone	Mining island of Yellowstone
114	76D	Lincoln	Granite Concrete Co. O	29N31W1B 30N31W14C	Cherry Creek/ Libby Creek & Libby Creek	Mine streambeds of Cherry Creek and Libby Creek at low flow
115	76G	Deerlodge	Montana Dept. of Highways I	5N9W7	Clark Fork	Pit has intercepted groundwaters high in iron and fluoride; no adequate reclamation plan for area has been proposed
116	76H	Ravalli	Donaldson Ready Mix O	7N20W31B	Bitterroot River	Mining streambed of Bitterroot
117	76H	Ravalli	A & B Concrete O	10N20W10	Bitterroot River	Inadequate settling, turbid waters discharged to slough which flows to Bitterroot
118	76H	Ravalli	A & B Concrete I	7N20W30CA	Bitterroot River	Pit opened illegally on actively eroding bank of Bitterroot
119	76M	Missoula	MonRoc O	13N19W17	Clark Fork	Mining gravel bar of Clark Fork; mining area floods yearly

Placer Gold Mining

	Drainage Basin Code	County	Operator	Location	Drainage	Problems Caused by Mining
150	41A	Beaverhead		11S13W 11S14W	Jeff Davis Creek/ Horse Prairie Creek/Clark Canyon Dam	Erosion/sediment deposition producing streamflow alterations
151	41B	Beaverhead		8S11W	Grasshopper Creek/ Beaverhead River	Severe sediment deposition producing stream flow alterations (approx. 24 km of stream affected)
152	41B	Beaverhead		6S12W	Dyce Creek/Grass-hopper Creek/ Beaverhead River	Sediment deposition producing stream flow alterations
153	41C	Madison	O	7S3W16	Browns Gulch/ Barton Gulch/ Ruby River	Erosion and sedimentation from placer operation
154	41C	Madison		7S3W 6S3W 6S4W	Alder Gulch/ Ruby River	Extensive placer mining since 1863 has left stream as a series of dredge piles;
155	41C	Madison		5S4W	Harris Creek/ Ruby River	Old placer workings; old dumps and tailings from hardrock minings impact streams as well as disturbance from placer mining; high spring sediment loads
156	41C	Madison		5S4W 4S4W	Ramshorn Creek/ Ruby River	"
157	41C	Madison		4S5W 4S4W	Mill Creek/ Ruby River	"
158	41C	Madison		4S4W	Indian Creek/ Ruby River	"
159	41C	Madison		3S4W	Wisconsin Creek/ Ruby River	"

160	41C	Madison		3S5W31,32, 33	Dry Georgia Gulch/ Ruby River	Old placer workings; old dumps and tailings from hardrock minings impact streams as well as disturbance from placer mining; high spring sediment loads
161	41C	Madison		3S5W20,21, 22,23	Goodrich Gulch/ Ruby River	"
162	41C	Madison		7S4W	Barton Gulch/ Ruby River	Old placer workings have caused sediment problems
163	41C	Madison		5S3W 4W	Bivin Creek/ Ruby River	Sedimentation; reduction of trout population
164	41C	Madison		5S4W	California Creek/ Ruby River	Sedimentation; reduction of trout population
165	41C	Madison		8S3W 9S3W	Warm Spring Creek/ Ruby River	Sediment deposition and stream channel alteration
166	41D	Silver Bow		1S8W	Moose Creek/ Big Hole River	Old placer mining still causing siltation problems
167	41D	Silver Bow/ Madison		2S8W	Camp Creek/Big Hole River	Old placer mining still causing siltation problems
168	41D	Silver Bow		2S8W6	Soap Gulch/Big Hole River	Old placer mining still causing siltation problems
169	41G	Madison		3S5W3,10,11	Bear Gulch/Jefferson River	Old placer workings; old dumps and tailings from hardrock minings impact streams as well as disturbance from placer mining; high spring sediment loads
170	41G	Madison		2S5W	Coal Creek/Jefferson River	"
171	41G	Madison		2S4W	Beall Creek/Jefferson River	"
172	41I	Broadwater	David Boomer Robert Carson O	11N1E2	Cooney Gulch/ Avalanche Gulch/ Canyon Ferry Lake	Discharges directly to creek, no settling ponds

173	41I	Broadwater		10N2E	Confederate Gulch/ Canyon Ferry Lake	High sediment loads in spring
174	41I	Lewis and Clark	Harold Ellingson Steve Walks O	12N1W21	Soup Creek/ Hauser Lake	Occasionally discharges to ephemeral drainage
175	41I	Lewis and Clark	Harvey Paul O	10N6W36	Walker Creek/ Tenmile Creek/ Hauser Lake	Pick and shovel work in streambed of perennial stream
176	76B	Lincoln		33N33W8	Yaak River	Discharges to stream; no obvious impacts
177	76E	Granite	Tim Gregori O	10N16W6	Solomon Creek/ Rock Creek	Very small operation with discharge to stream; no apparent impacts
178	76F	Lewis and Clark		14N9W	Beaver Creek/ Blackfoot River	Occasional sediment problems
179	76F	Lewis and Clark		14N9W	Stonewall Creek/ Blackfoot River	Occasional sediment problems
180	76F	Lewis and Clark		14N8W 14N9W	Keep Cool Creek/ Blackfoot River	Occasional sediment problems
181	76F	Lewis and Clark		13N8W16	Poorman Creek/ Blackfoot River	Very small placer mining; dozing into creek
182	76F	Powell		12N8W 12N9W	American Gulch & Washington Creek & Jefferson Creek Madison Gulch & Buffalo Creek/ Nevada Creek/ Blackfoot River	Intermittent placer workings; worked by small mines each year
183	76F	Powell		13N11W 12N11W	Douglas Creek & Nevada Creek/ Blackfoot River	Past siltation evident; ground clayey and swampy
184	76F	Missoula	O'Loughlin Austin D'Orazi O	13N14W23, 25,36	Elk Creek/ Blackfoot River	Mining in bed of stream and/or discharging to stream; sedimentation

185	76G	Deerlodge		2N10W6,5	German Gulch/ Silver Bow Creek/ Clark Fork	During high water, creek runs with high loads braided channel
186	76G	Powell	Clark J. Smith O	11N7W19AA	Ophir Creek/ Carpenter Creek/ Little Blackfoot River	Discharge from small operation
187	76G	Powell		9N11W	Gold Creek/ Clark Fork	Siltation, N. & S. Forks, N. Fork diverted into S. Fork; severe erosion problems
188	76GJ	Granite		8N12W	Little Gold Creek/ Flint Creek	Diversion over glacial debris
189	76M	Mineral	Arpan O	15N26W18,19	Trout Creek/ Clark Fork	Small placer operation with discharge to stream; no obvious impacts; operates in streambed and floodplain
190	76M	Mineral	Coleman Brothers O	15N26W26	Meadow Creek/ Clark Fork	In spring, discharges to stream; does not have settling pond; downstream sedimentation problems
191	76M	Mineral	Pete Balison O	15N25W31	Quartz Creek/ Clark Fork	Discharges to stream; in past, settling ponds have inadequately settled discharge
192	76M	Missoula	Clay Lewis O	17N24W21	Ninemile Creek/ Clark Fork	Mine discharges to stream but no apparent problems except physical disturbance of stream bed and floodplain
193	76M	Missoula	John Woodens O	16N23W10	Little McCormick Creek/McCormick Creek/Ninemile Creek/Clark Fork	Discharges to stream in spring; inadequate settling facilities
194	76M	Missoula	Fluto O	16N23W14	Favorite Gulch/ McCormick Creek/ Ninemile Creek/ Clark Fork	Discharges to stream; have corrected past settling pond problems
19L	41D	Beaverhead	Jack DeBore O	3S17W	Little Goosehorn Cr/Ruby Cr/ Big Hole River	Placer work beginning, discharge to stream through pond

quality were identified. Nineteen problems or suspected problems associated with sand and gravel mining were identified, and forty-four streams or drainage basins were noted as being adversely affected by placer mining.

Major concentrations of hard rock and other mining impacts are found in Sanders and Mineral Counties in the lower (76N) and middle Clark Fork (76M) drainages; in Granite, Powell, Deer Lodge, and Silver Bow Counties in the Flint Creek (76GJ), and upper Clark Fork (76G) drainages; in Beaverhead County in the Beaverhead River (41B) drainage; in Cascade and Judith Basin Counties in the middle Missouri River (41Q) drainage; and in Phillips County in the middle Missouri River (40EJ) and People's Creek (40I) drainages.

Impacts from sand and gravel mining are found throughout the state, from Richland County to Lincoln County. Major streams impacted include the Bitterroot, Clark Fork, Teton, and Sun Rivers. Gold placer mining has had its greatest impact in Beaverhead, Madison, Lewis and Clark, Powell, Broadwater, Missoula, and Mineral Counties. Nearly every county which experienced placer mining in the past still experiences some impact from these activities.

The 131 identified specific problems can be grouped into several type categories:

Problem Type	Percent
Mine Drainage	17
Tailings and waste dump erosion	34
Placer workings	35
Sand and gravel mining	12
Roads and ground disturbance	2

Thus, placer working and erosion of tailings and waste dumps are the most numerous mining related problems in the state. Although not as numerous, mine drainage problems may be more significant in water quality impact than placer working. The effects of roads and ground disturbance are generally of lesser significance, resulting in sedimentation impacts.

Seventeen major problems have been selected in the Statewide 208 Area (Table 12). These problems have been selected based on the extent and severity of water quality impacts, length of affected stream, and extent of mining area. In some cases, selected problems are grouped into a mine district. For example, in the Sand Coulee Mine area, nine old mines discharge acid waters to the stream. In other cases, the water quality problems results from more than one aspect of mining, e.g. erosion of tailings and acid mine drainage. Of these major problems, 53 percent are principally caused by erosion of tailings and waste dumps, 35 percent are mine drainage related, and 18 percent are related to old placer workings.

EVALUATION OF COSTS OF CORRECTIVE MEASURES

Since there are a multitude of water quality problems in the state related to activities such as mining, agriculture, and silviculture, it is important to estimate the cost of eliminating or abating problems of all types. Although this study did not individually examine each identified problem, it is possible to estimate in a gross manner, the cost of solving identified problems, based on data available from other studies (McArthur, 1970; DNRC, 1978; and DNRC, unpub.).

Table 12 Summary of Major Mining Related Water Quality Problems in Montana Statewide 208 Area

County (Basin)	Location*	Mine or District	Receiving Water/ Major Stream	Mine Type	Problem	Problem Status
Phillips (40EJ)	25N24E15D	Little Ben Mine	King Creek/ Peoples Creek/ Milk River	Silver-Hardrock	Erosion of tailings and deposition into stream	No work on problem known
Beaverhead (41B)	8S11W8B	Bannack	Grasshopper Creek/ Beaverhead River	Gold Leaf Mill Gold Placer	Erosion of old mill tailings into stream. Old hydraulic mining banks eroding. Metals and sediments problem. Approx. 24 km of stream affected.	Preliminary investigation completed. Conceptual abatement plan developed.
Madison (41C)	7S3W16	Virginia City	Browns Gulch/ Barton Gulch/ Ruby River	Gold Placer	Erosion of disturbed placer areas. Deposits and sediment in stream.	No work on problem known
Jefferson (41E)	7N5W19,20	Crystal Mine	Uncle Sam Gulch/ Cataract Creek/ Boulder River	Silver-Hardrock	Erosion and sediment transport from pits and wastes. Acid mine discharges. Sediment, metals and acid problem.	Technical investigation completed. Legal action being taken by DHES.
Jefferson (41E)	7N5W36	Comet Mine	High Ore Creek/ Boulder River	Silver-Hardrock	Erosion of old mill tailings. Some acid water production. Sediment and metals problem.	Preliminary investigation completed. No further action.
Judith Basin (41Q)	15N9E6,7	Hughesville District Block P Mine	Dry Fork/ Belt Creek/Missouri River	Silver-Hardrock	Acid mine waters from old adits and waste dumps. Metals, sulfate, acid problems. Effects extend to Belt Creek.	Technical investigation completed. Corrective measures developed; corrective progress planned but not funded.
Cascade (41Q)	14N8E 10,27-33	Neihart District	Carpenter Creek/ Belt Creek/ Missouri River	Misc.-Hardrock	Acid mine drainage from mine workings and from waste rock dumps. Metals, acidity, sedimentation problem.	No work on problem known
Cascade (41QJ)	20N4E	Sand Coulee Mining Area	Sand Coulee Creek/ Missouri River	Coal-Underground	Acid mine drainage from 9 old mines. Sediment, coating of stream bottom, metals, acid problems. Extends to Missouri River.	Technical investigation completed. Corrective measures outlined. No action on corrective plan.

Lewis and Clark (41QJ)	13N7W10	Gould Mine	Gould Creek/ Fool Hen Creek/ Canyon Creek/ Little Prickly Pear Creek/	Gold-Hardrock	Acid mine drainage; erosion of waste dump	No work on problem known
Park (43C)	9S14E10,11	McLaren Mine New World District	Daisy Creek/Stillwater River	Gold-Hardrock	Precipitation infiltration into wastes and disturbed areas. Acid mine drainage, metals, sediment. Daisy Creek aquatic community depressed and devoid of fish for 1.8 miles downstream from mine.	Technical investigation completed. Corrective measures developed; corrective program planned but not funded.
Park (43C)	9S14E2,11	Glengary Mine New World District	Fisher Creek/ Clark Fork of Yellowstone River	Gold-Hardrock	Infiltration of precipitation into mine workings. Acid mine drainage -- metals, sulfate.	Technical investigation completed. Corrective measures developed; corrective program planned but not funded.
Lincoln (76B)	28N32W11	Snowshoe Mine	Snowshoe Creek/ Kootenai River	Misc.-Hardrock	Drainage from tailings contains metals; toxic to fish.	No work on problem known
Lewis and Clark (76F)	15N6W28	Heddleston District Mike Horse Mine	Blackfoot River	Silver, Copper, Lead, Zinc-Hardrock	Acid mine drainage from several mines but Mike Horse Mine is major problem; tailings dam burst and deposited sediment downstream.	Reconnaisance investigation completed. No further action.
Missoula (76F)	13N14W16	Elk Creek Placers	Elk Creek/ Blackfoot River	Gold Placer	Erosion of disturbed area. Erosion and deposition into stream.	No work known on problem
Granite (76G)	9N12W22	Forest Rose Mine	Dunkleburg Creek/ Clark Fork River	Misc.-Hardrock	Acid mine drainage; erosion of tailings; culvert plugged - additional erosion will occur.	No work on problem known

Silver Bow (76G)	3N8W 1,2,11-15	Butte Mining District	Silver Bow Creek/ Clark Fork River	Copper	Effluent from mining facilities and major pollutant input from old tailings deposits in Silver Bow Creek. Sediment, metals, sulfate problem. Stream aquatic community depressed in Silver Bow Creek.	Major correction of problem by Anaconda Company contribution completed. Additional corrective actions being investigated for stream system.
Powell (76G)	9N11W		Gold Creek/ Clark Fork River	Gold Placer	Erosion of disturbed areas from stream diversions and mining	No work on problem known
Granite (76GJ)	7N13W	Philipsburg District	Flint Creek	Misc.- Hardrock	Mercury from gold recovering operations in stream. Tailings erosion; adit discharges. Sediment and metals problems.	No work on problem known

Generally, mining problems are related either to erosion by streams or overland flow or are related to mine drainage.. Erosion problems can usually be corrected by stream alterations or removal of eroding material. Eroding material at placer and sand and gravel mines is usually inert and poses only a sedimentation problem to streams. Erosion of waste dump or tailings, however, may have chemical impacts to streams. Solutions to mine drainage problems involve separating contact between water and reactive materials (Chapter IX). Site specific solutions must be determined on a case-by-case basis.

Solutions to placer and sand and gravel problems commonly involve separating water by diversion from eroding materials or reclamation of mined areas to allow water to move through the workings. Correction of these problems is less expensive than work related to waste dump and tailings problems.

Mine tailings and waste dump problems have different solutions in that tailings are typically very erosive and can create serious chemical pollution problems and commonly are difficult to reclaim. Similarly, waste dumps, generally are not as susceptible to erosion as tailings, but can create chemical problems and are difficult to reclaim. Solutions to mill tailing problems have involved tailings removal, control of infiltration, and water diversion. Diversion ditches typically cost from $1 to $3 per cubic yard of material removed and diversion dikes from 35 to 65 cents per cubic yard (EPA, 1973). The objective of diversion is to collect water before it reaches erodible materials. This is usually accomplished by excavation of ditches on the high end of the mine or construction of dikes peripheral to the tailings. Erosion control utilizes vegetation and topsoiling to control movement of tailings. Cost of erosion control is highly variable

and depends on adaptibility of the region to revegetation, climate, and availability and cost of topsoiling. Within Montana a good example of reclamation of a tailings area is at the McClaren Mill site near Cooke City, Montana. The McClaren mill tailings cover approximately 11 acres and discharge a highly acidic water into adjacent Soda Butte Creek. The cost of transporting and disposing of 113,000 cubic yards of tailings was estimated to be $139,400 or about $1.23 per cubic yard. This estimate presumed hauling tailings to a site within 8 kilometers of the mill, topsoiling, and seeding (DNRC, unpub.).

Waste dumps present problems similar to tailings except that waste dump materials are larger, contain some barren rock materials, and are less susceptible to erosion. The techniques for handling waste dumps are similar to those for tailings, that is, water can be excluded from the waste dumps, erosion controlled, water diverted around the dump, or the dump materials can be removed. At most mines, there is substantially more waste than there is ore, and the amount of waste normally is much greater than the amount of tailings. For this reason, the technique of removal is often limited due to the great volume of waste. A specific study in Montana relative to waste dumps was done at the Hughesville area on Galena Creek, which is a tributary to the Dry Fork of Belt Creek, tributary to Belt Creek. At this site, there were numerous problems including acid mine drainage from adits and shafts present at the area, and acid mine drainage from infiltration into a large waste dump associated with the Block P mine. This waste dump located on a steep hillside, was approximately 200 feet long by 150 feet wide, and extended about 1,000 feet along the hillside. Regrading and sloping of this dump, together with sealing of the dump top and topsoiling, was estimated to cost $50,650 (DNRC, 1978). Removal of the dump material was estimated to cost $256,340. The waste

dump at this site was relatively large compared to most waste dumps in Montana. Work at this site has only improved water quality somewhat, but other mining related impacts still exist.

Another site investigated for treatment or elimination of the pollution problem of a waste dump was at the McClaren Mine site near Cooke City, Montana. Waste covered an area of approximately 8 hectares, and contained approximately 82,600 cubic meters of material (DNRC,unpub.). The area is a high quality alpine environment, however, the mining impacts and the size and nature of the mining disturbance was similar to other mining areas in Montana. Cost for regrading, and diversion ditch work, and vegetation of this area is estimated to be $292,100 (DNRC,unpub.).

Corrective techniques for acid mine drainage problems vary widely depending on character of the mine water, location of the mine, treatment possibilities, the nature and geography of the system. A great deal of work and research has been done on correction or abatement of acid mine drainage problems, and a large variety of solutions have been developed (Chapter IX). One mine in Montana studied for correction of acid mine drainage problems is the Glengarry Mine, on Fisher Creek near Cooke City, Montana. This area is contributing acid mine water to the nearby stream. Solutions for this problem involved adit seals, and estimated cost for bulkhead sealing of this mine isestimated to be $54,000. This adit is typical of many mines in Montana that flow acid mine water, except, that this adit can be entered and has relatively stable walls. Many mines in Montana are unstable, cannot be re-entered, and are difficult to investigate.

Another study of acid mine drainage control (McArthur, 1970), shows that the cost of neutralizing acid mine drainage from coal mines in the Sand Coulee area is estimated to be $11,140 (capital cost) with an annual operation and maintenance cost of $7,240. A proposed mine flooding facility to flood one of the mines is estimated to be $16,100. These estimates do not include additional detailed testing of mine waters.

Cost of correcting all mine problems in Montana is of interest, however, there is insufficient data to make any detailed cost estimate, and costs depend on each specific mine site. An order of magnitude estimate, or more candidly, a guess at gross costs, can be made by taking the number of mine problems in each category and multiplying by a cost per problem including costs for necessary preliminary and detailed engineering studies.

The following is a crude order of magnitude estimate as to the cost of correcting mining related problems in Montana identified in this report. Assuming the distribution of problems in Montana is similar to that determined in this study and that the number of mine problems is 131, the following costs are estimated.

Preliminary problem examination	$150,000 to 500,000
Detailed technical studies	1,000,000 to 5,000,000
Tailings pollution problems (27)	1,500,000 to 8,000,000
Waste dumps (16)	1,500,000 to 3,000,000
Acid mine drainage (22)	1,000,000 to 6,000,000
Placer operations (45)	500,000 to 2,500,000
Sand and gravel	20,000 to 150,000
TOTAL	$5,675,000 to $25,150,000

It must be recognized that each problem needs to be assessed relative to its individual corrective cost and benefit, and that many problems may be only partially corrected. Another consideration is that not all mining related problems in Montana are known and additional details surveys of mining problems are needed to determine the full impact of mining problems.

Each solution to a mining problem in itself involves a disturbance and has an environmental consequence. Benefits associated with correction of a problem commonly are increased recreational use of water, greater stream productivity, improved usefulness for irrigation, domestic and stock purposes, and increased land values. Costs of correcting mining problems includes not only the actual monetary costs, but also the use of these monies to correct other non mining problems. Priorities obviously must be established. During the corrective process, there may be a temporary decline in water quality which may last some period of time after the correction. The objective in evaluation of mining problems is to select projects that have maximum environmental and monetary benefits and have a minimum cost environmentally and financially. Several problems in Montana have been examined and measures have been applied to correct these problems, but the entire spectrum of mining problems and associated corrective measures is poorly known.

DRAINAGE BASIN ASSESSMENT OF PROBLEMS

Although past, existing, or future mining affects almost every drainage in the state, there are obviously some areas where mining impacts have been, or may be, the most significant. Identification of these areas can assist the Water Quality Bureau in developing management programs to correct existing problems and anticipate future problems. Appendix D outlines each state drainage basin, the locations of all operating permits, the locations and developable minerals in each mining district, and an assessment of the extent of current exploration and future development potential in each basin. Those basins experiencing the most significant levels of mining development are described below.

The upper Clark Fork including Flint Creek, drainage basin has the most hard rock operating permits (7) in the state and the most identified mining related problems, other than those associated with placer mining. This basin is highly mineralized and includes the Anaconda Company operations, the Black Pine Mine, and four limestone or silica mines. Much of Deer Lodge, Granite, Powell, and Silver Bow Counties lie within this basin, and there are 141 small miner operations in these four counties. Exploration activity in the basin is significant in both the Flint Creek range and the Boulder batholith area. Phosphate reserves are extensive around the Flint Creek range and north of Garrison. Applications for oil and gas leasing have been received for most of the Flint Creek range.

The Beaverhead River drainage basin has five operating permits, all related to talc mining in the Ruby Range, six identified mining problems and two drainages affected by placer mining. Mineralization is high and there is a strong potential for future development in the basin. Natural gas reserves can be reached by drilling in the Centennial Valley.

The Missouri River drainage, Holter Lake to Three Forks, has a number of quarry operations, and several identified problems related to hard rock and placer mining. Numerous discharging abandoned mines in the Boulder batholith have been identified by Pedersen (1977). Exploration for uranium, molybdenum, and silver is currently underway south of Helena.

Pedersen has summarized his research:

> Investigations of the Boulder River from Basin to Boulder, Ten Mile Creek, Little Blackfoot River, and Prickly Pear Creek drainages were conducted from April through September, 1977. Existing degraded water quality resulting from acid mine wastes and reclamation necessary to alleviate water quality problems were determined. 56 of 66 stream locations had metal concentrations exceeding those known to have an adverse effect on aquatic organisms. The major problems in the Boulder River drainage are acid, metals, and sediment from the Crystal Mine on Uncle Sam Gulch and the Comet Mine on High Ore Creek. Mines in and near Rimini (Valley Forge, General, Lee Mountain, and the mine just above Rimini) and Upper Minnehaha Creek (Justice Mine) are the greatest pollutant contributors to the Ten Mile Creek drainage. Lily-Orphan Boy Mine has a great impact on Telegraph Creek in the Little Blackfoot drainage. Spring Creek contributes a tremendous load of acid, sediment, and metals to Prickly Pear Creek. These sources of pollution are: a mine on Wood Chute Creek, Washington Mine, and tailings piled in Corbin. Clancy Creek (a tributary to Prickly Pear Creek) is affected by mine waste from the Gregory Mine in its upper reaches.

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MINERAL FUELS AND WATER QUALITY

Coal

There has been little coal mining to date in the Statewide 208 Study Area. The most significant water quality impacts in the study area have been experienced in the Sand Coulee drainage basin, Cascade County. As described by McArthur (1970) nine abandoned mines discharge acidic waters which affect about 20 miles of stream and affected waters sometimes reach the Missouri River.

If coal production expands in the Statewide 208 Area, it will take place in eastcentral Montana, a region where lignite is presently produced at the Knife River Coal Mining Company Mine near Savage, Richland County. No significant water quality problems have developed at this mine, which is located about five miles upstream from the Yellowstone River on an ephemeral drainage. This mine has applied for an MPDES discharge permit for discharges through settling ponds, of mine pit waters and runoff from disturbed areas. Two small mines operate in the Bull Mountains, Mussellshell County, but have not caused water quality problems, due to their small size and location in a dry, drainage divide area.

To date, coal mining in Montana and in the Statewide 208 Area has not been free from water quality problems. A substantial amount of research has been done concerning the general effects of coal strip mining on hydrological systems (Van Voast, Hedges, and McDermott, 1977; Van Voast and Hedges, 1975; McWherter, et.al., 1977). The general conclusion of Hardaway, et.al. (1977) is noteworthy: "There is no strong evidence of chronic water pollution caused by the current coal mining operations in the interior western United States." Hardaway, et.al. (1977) note that limited degradation from sedimentation has

occurred in some streams, for example, Little Youngs Creek at the Public Service Company of Oklahoma Mine near Sheridan, Wyoming. At most other site, however, impacts have either not been noted or else there is insufficient or incomplete data available to make detailed assessments. Certain problems, however, remain of concern, and cannot be considered resolved.

Van Voast and Hedges (1975) have shown that the Decker Mine has dewatered aquifers, with measurable effects within two miles of the mine. Such dewatering is probable with any large excavation. The more significant questions relate to re-establishment of aquifers and groundwater gradients at the conclusion of mining. In time, when mining and reclamation are completed, flow patterns are expected to be re-established. However, there is little direct evidence in Montana to determine the nature of post-mining groundwater systems. Final Interim Regulations for the federal strip mine bill require that a mined area be returned to its former role in the hydrologic system, including re-establishing the recharge capacity of the area. These regulations essentially require that aquifer systems be re-established.

Research at Decker and Colstrip also shows that post-mining groundwater quality is generally inferior to pre-mining groundwater quality (Van Voast, Hedges and McDermott, 1977).

Hardaway, et.al. (1977) conclude: "that spoiled overburden contains groundwater of poorer quality than in nearby undisturbed overburden and water-bearing coal seams, and thus that newly spoiled overburden has the potential, at least in selected circumstances, to produce groundwater of relatively poorer quality."

In no case have the specific impacts of increased mineralization of groundwater from coal strip mining been shown to degrade a regional aquifer system in Montana. No research, however, has been conducted on projecting the impact of concentrated mining on regional systems, such as in the Decker/Sheridan area.

Erosion and sedimentation problems will be a function of the successful operation of installed treatment facilities and the success of reclamation. Treatment facilities are now required to treat all runoff from lands disturbed by mining, and settling ponds must be maintained until bond has been released on reclaimed watersheds. This requirement had been generally enforced by the Reclamation Divison prior to development of the federal regulations.

Erosion problems have been experienced at many coal mines, with gullying cutting four-foot-deep channels in places. After a ten-year storm event at Colstrip in 1976, one reclamation stream channel experienced net scour of almost two feet (J. Schmidt, unpub.). Sheet erosion is believed to be accelerated during reclamation but little quantitative work has been completed.

If settling ponds are maintained until after erosion rates return to those of surrounding areas, and if revegetation efforts continue to be successful, erosion and sedimentation in adjacent streams should not become a problem.

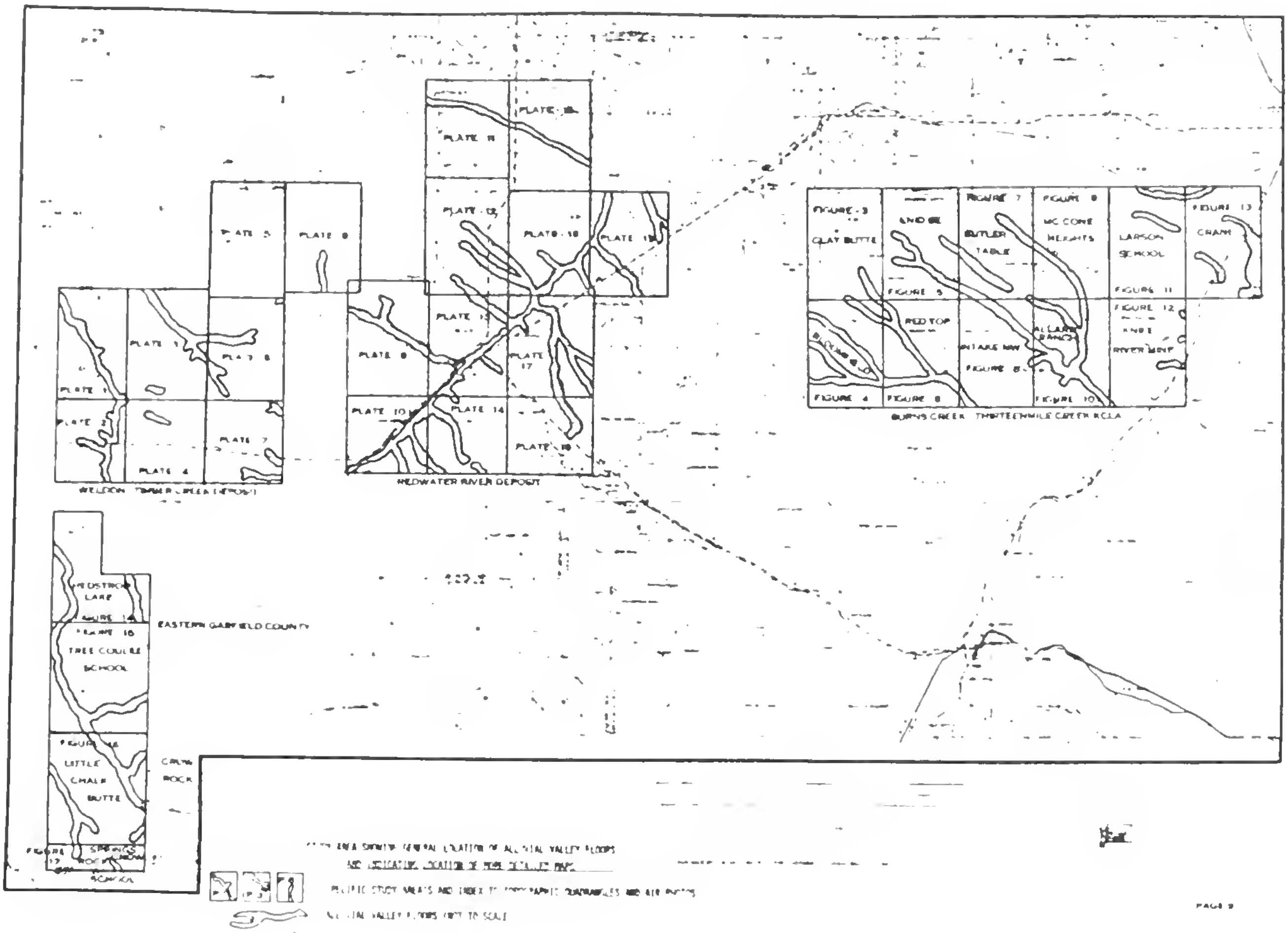
In the Statewide 208 Area, Knife River Coal Mining Company has been cited and fined for non-compliance with the Montana Strip and Underground Mine Reclamation Act regarding uncontrolled erosion at the mine which led to sedimentation in two small coulees, tributary to ephemeral Garden Coulee. In the past, Knife River is reported to have discharged directly from their

mining pit to these small coulees, resulting in coal debris depositing in the drainages (Robert Etzel, pers. comm.). Substantial work has been done at the Knife River Mine to prevent future sedimentation problems.

A significant level of protection of surface and groundwater quality in valley fill areas is afforded by the Surface Mining Control and Reclamation Act of 1977 and adopted Interim Regulations (Chapter XII). Alluvial valley floors have been mapped in portions of Dawson, Garfield, McCone, and Richland Counties (Schmidt, 1977). Mapped areas include the Weldon-Timber Creek coal field, site of the proposed Circle-West Project (Burlington Northern Railroad), the Redwater River coal field, downstream of the town of Circle, and the Burns Creek-Thirteen Mile Creek coal field, between Glendive and Sidney. Streams mapped as alluvial valley floors include the mainstem and major tributaries of Little Dry Creek (drainage basin 40D), Big Dry Arm of Fort Peck Reservoir (40E), Redwater River (40P), and the Yellowstone River (42M) (Figure 8). Alluvial valley floors can also be expected to be found in association with strippable coal deposits in the Beaver Creek drainage (39G), Big Muddy Creek drainage (40R), and possibly in the Bull Mountains coal field (40A). Coal fields in western Montana have not been investigated for the relationship of alluvial valley floors and strippable coal reserves.

Although only a small percentage of strippable coal underlies alluvial valley floors, mining near these areas must demonstrate that the hydrologic balance of the valley system will be maintained during and after mining. If the present Interim Regulations remain in effect, water quality in valley floor systems will be substantially protected by the alluvial valley floor provisions.

Figure 8 - Study Area Showing General Location of Alluvial Valley Floors and Indicating Location of More Detailed Maps



(Schmidt, 1977)

Mine operators are required to re-establish aquifers and aquicludes, stream channel characteristics and water quality. Excavations in alluvial valley floors, considered by many to be the most sensitive of all aspects of strip mining, will be carefully monitored in the future.

Oil and Gas

The search for oil and gas involves much technology, capital expenditure and surface disturbance. In recent years, oil and gas activities have increased with new field discoveries and much leasing and exploration. Newer wells typically are in deeper zones, some probing levels three to four miles below the surface. Both the depth and areal coverage of oil and gas activities are increasing.

Impacts of oil and gas on water quality are related to three phases of operations. The exploration phase involves seismograph activity, wildcat drilling, and exploratory wells. The development and production phase involves intensive drilling and associated construction activities. Both these phases require building and maintainence of drill sites, access roads, drilling and reserve mud pits, and installation of production facilities. The third phase of hydrocarbon activity that is important is abandonment and plugging of holes, and reclamation of roads, pit and drilling areas. Each of these phases has potential for water quality degradation.

Seismograph exploration consists of examining subsurface stratigraphy, hopefully pointing to areas with potential for oil and gas. An impulse is required, either by mechanical thumpers or, more commonly, with explosives that generate a signal to seismic measuring instruments. Large trucks are used for these purposes, generally transversing unroaded land. When explosives are used, holes are drilled to depths of 50 to 200 feet. Cuttings are often left around the mouth of the hole, with little effort taken to revegetate disturbed areas. The explosion throws additional rock and soil for a short radius around the hole and introduces nitrates from the explosives to the shot hole. Surface impacts are mainly due to increased erosion from wheel tracks and improper disposal of shot hole cuttings.

The drilling of wildcat, exploratory, and production wells all basically involve the same methods and technologies. A drill pad is constructed on a level area from one to five acres in size. An all-weather road capable of handling large trucks is usually constructed, and pits are dug for storage of drilling mud. Roads and drilling sites are generally potential sites of non-point pollution.

Another potential for water quality degradation occurs when drilling intercepts water, brines, or oil. These fluids must be controlled to avoid both surface and subsurface pollution. If oil and gas are not encountered in economic quantities, the hole is plugged and abandoned. If the well is successful, storage facilities are built on the pad and/or a pipeline is laid to the nearest collection line. If brine is produced with the oil, it can be stored in brine pits, reinjected, or discharged to surface waters. Discharges to state waters are regulated by the Water Quality Bureau, if they are known to exist.

Another hazard to surface water quality during the production phase is one of oil or other toxic fluid spills from pipeline breaks, storage facilities, tanker accidents, and refineries. These problems are not considered in this report, but are a potential problem in hydrocarbon development and production.

When wells are abandoned, the usual procedure is plugging and regrading and revegetating disturbed areas. Regulatory control over the plugging operation is difficult since there is no way to check whether it is done correctly, without being at the scene during plugging activity, or by drilling the plug out on a spot check basis. If holes are not plugged properly, there is a chance of intermixing of aquifer fluids should the casing corrode and leak. If waters encountered in drilling have sufficient heads, improperly plugged

holes could discharge to surface waters at a later date. Depending on the area this could cause problems in salinity, and temperature in surrounding waters.

The Montana Oil and Gas Commission, USGS Conservation Division, Montana Bureau of Mines and Geology, and three major producers were contacted regarding water quality problems associated with oil and gas production. Contamination of water wells by natural gas is difficult to determine because it is odorless, colorless, and tasteless. Water is a problem in production of natural gas and must be removed from the gas. The U.S. Geological Survey and Oil and Gas Commission know of no surface water or groundwater problems associated with natural gas production in Montana.

The interaquifer transer of water, that is, the movement of water from brine zones to fresh-water zones, or the loss of water from fresh-water zones into brine zone, probably is the greatest potential water quality problem associated with gas production. Both the U.S. Geological Survey and the Montana Oil and Gas Commission have permissive, not mandatory rules relative to well plugging and abandonment. Disposal of the small quantities of water separated from natural gas is done in several ways, by reinjection into the subsurface formations, and by evaporation and use on lawns. The only water quality problem reported in the Statewide 208 Area is the natural gas contamination of a water well in the Cutbank area.

There have been very few water quality problems relative to oil development in the Statewide 208 Area. One problem reported concerned a water well in the Cutbank area that may have been affected by brine injection by the Union Oil Company (J. Sweet, Oil and Gas Commission, pers. comm.). Discussions with the USGS, Conservation Division, indicate that a few other problems have

occurred in Montana. One problem on the Fort Peck Indian Reservation concerned pollution of wells and there was a spill of oil-based muds into Swift Reservoir from an oil well test hole (Lee Pauli, pers. comm.). The USGS feels that the overall impact of road construction, site development, mud pits, and reserve pits, is very small and that few problems occurred from these activities.

Another problem mentioned by numerous people in Montana relative to water quality problems associated with oil and gas development is the problem of old wells drilled many years ago with poor casings and improper cementing. It is thought that many of these wells have probably corroded and may be allowing interaquifer transfer of waters. Since investigation of deep subsurface water pollution is very expensive, little or no effort has been made to assess this problem.

Uranium

No uranium mining currently takes place in Montana. Reserves have been discussed in Chapter VIII. There is the possibility of future uranium mining in the state. Industry has considered developing uranium reserves through surface mining and through solution mining using extraction wells. Although mining is not taking place, it is important to consider the potential impacts of future uranium developement.

Aspects of the uranium development process where possible effects on water quality might occur, include: exploration activities, various mining methods, and various milling methods. Mining and milling techniques include open pit-acid leach processes, underground mine-acid leach processes, underground mine-alkaline leach processes, and mining processes. Major aspects of potential water quality impacts from uranium mining relate to problems of tailings disposal of processed materials and disposal of toxic liquids in aquifers. The problems related to reclamation of uranium mined lands are also in question. The water quality impacts associated with uranium exploration are not dissimilar from water quality impacts associated with exploration of other minerals. Some minor alterations to streams can occur from road building activities and drilling operations, as well as disposal of drilling muds. The Coal and Uranium Bureau, Montana Reclamation Division, discourages drilling activities near stream channels. As with other drilling activities, the possibility of groundwater disruption due to mixing of aquifers in poorly sealed holes and draining of artesian aquifers is a possibility.

Nationally, a major environmental impact associated with open pit mining is pit dewatering. The establishment of an open pit mine creates a regional drain on the groundwater system similar to that observed at coal strip mines and this dewatering may affect other water users in the vicinity of a mine. Wells drilled to intercept waters around the mine are often discharged without any treatment (Reed, A.K., et.al., 1976). Existing uranium mines have mine dewatering rates ranging from 200 to 3000 gpm. Mine waters may contain uranium, selenium, zinc, sodium, sulfates, nitrates, and other substances. The specific composition of the mine waters varies with the composition of the aquifers intercepted and the rock formations encountered in the pit. Mine discharge waters also contain suspended solids. Tables 13 and 14 show representative samples from a number of existing uranium mines in the United States.

Generally, discharges from acid and alkaline leach systems range from 250 to 1000 gallons per metric ton of ore processed. Although recycling of liquids reduces discharges, wastes must inevitably be disposed. Waters used in leaching operations must be developed from surrounding wells which have a regional dewatering affect on the system. Liquid wastes from mills are aqueous solutions containing various chemcials, leached elements, and suspended ore finds, and other solids. Table 15 is an analysis of an alkaline leach mill effluent. Liquid wastes from milling operations generally are discharged through a settling pond, but in the past, were discharged directly to stream channels (Reed, et. al., 1976). These solutions from alkaline leach processes have a pH of between 9.5 and 11.0 from the unreacted carbonate-bicarbonate leach solutions. This leaching process is relatively specific for uranium and does not leach out many other minerals from the ore. A portion of the alkaline process water is discharged to a tailings pond to

TABLE 13 COMPOSITION OF DISCHARGE WATER FROM MINES[a]

Applicant / Mine Designation / Mine Location	Surface Mines			Underground Mines			
	Kerr-McGee Shirley Basin, Wyoming	Getty Oil KGS-JY-Mine Shirley Basin, Wyoming	Utah Intl. Shirley Basin Shirley Basin, Wyoming	Cotter Corp. Schwartz-walder Golden, Colorado	Union Carbide Eula Belle Uravan, Colorado	Union Carbide Martha Belle Uravan, Colorado	Union Carbide Burro Slick Rock, Colorado
Flow rate, $m^3/day \times 10^3$	1.7	5.4	10.9	0.3	0.3	0.2	0.1
pH	7.9	7.5	6.7-8.2	7.3	8.6	8.4	8.8
Alkalinity	180	164	144-150	244	358	384	704
Total Solids	612	840	850-1,275	1,220	730	3,103	1,790
Total Dissolved Solids	411	627	750-825	1,042	590	650	1,780
Total Suspended Solids	163	49	40-420	178	140	2,453	6
Total Volatile Solids	38	164	40-92	244	70.7	192	125
Ammonia (as N)	0.22	1.33	1.42-1.60	0.15	<0.10	<0.10	3.3
Kjeldahl Nitrogen	0.22	1.33	1.42	0.55	145	0.3	21.8
Nitrate (as N)	<0.01	0.002	0-1.06	12.0	0.35	0.39	1.9
Phosphorus Total as P	0.05	0.07	2.30	0.4	0.2	0.4	0.15

Source: Reference 12.

(a) Compo·.·ion data given in mg/l unless otherwise specified.

(Reed, et.al. 1976)

TABLE 14. COMPOSITION OF DISCHARGE WATER FROM UNDERGROUND MINES

Operator Designation Location	Kerr-McGee[a] Sec. 30W Grants New Mexico	Kerr-McGee[a] Sec. 35 Grants New Mexico	Kerr-McGee[a] Sec. 36 Grants New Mexico	United Nuclear[a] Churchrock Mine D Grants New Mexico	Kerr-McGee[a] Churchrock Grants New Mexico	Rio Algom[b] Humeca La Sal Utah
Flow rate (m^3/day x 10^3)	5.1	14.3	8.4	7.8	8.3	
pH						7.6
Total dissolved solids						2962
Total suspended solids	22	100	38	118	47	
Total solids						3712
SO_4			13			300
Cl	51	8.5		4.9	1.2	1597
Fe						0.16
Mo	2.6	5.0	0.3	0.2	0.2	
Na	160	200	187	95	97	1335
NH_3	19	11	0.05	0.05	0.05	N.D.
$NO_2 + NO_3$	1.14	0.35	0.25	0.22	0.53	
NO_3						9.5
Se	0.03	0.07	0.01	0.04	0.01	<0.005
V	0.7	0.8	0.9	0.5	0.8	
Mn	0.7	0.05	0.11	0.09	0.8	N.D.
Total U	4.7	19	3.0	10.4	0.88	0.035

(a) Average concentrations in mg/1; Source: Reference 11
(b) Average concentrations in ppm; Source: Reference 13

(Reed, et.al., 1976)

TABLE 15

ANALYSIS OF AN ALKALINE LEACH MILL TAILINGS EFFLUENT

Solution Analysis	ppm
U_3O_8	6.8
Mn	0.01
Cu	0.01
Fe	1.0
Zn	0.6
SO_4	7,500
CO_3	4,000
HCO_3	1,100
Th	2.0
Na	7,100
pH	9.5

Solids Analysis	Percent
U_3O_8	0.017
Mn	0.01
Cu	0.0028
Fe	1.36
Th	0.0005

Source: Reference 13.

(Reed, et.al., 1976)

prevent buildup of dissolved solids while the remainder of the process water is recycled through the plant.

Waste from acid leaching processes have a pH of between 1.5 and 2. These waters contain the unreacted portions of the sulfuric acid leaching agent and other soluble inorganics such as calcium, sodium, magnesium, and iron. Small amounts of other metals leached from the ore may be present. In this process, one to three percent of the ore may be dissolved in the process wastes. The major organics present in the acid process water are those of the raffinate solution (primarily kerosene, amines, and isodecanol). A mill processing 2000 tons of ore per day produces 3000 tons per day of waste milling solution (Reed, et.al., 1976).

The quantity of seepage from tailings ponds varies depending on pond design. In evaporation-percolation ponds, seepage may account for up to 85 percent of all losses. However, in clay-lined ponds where there is a tailings buildup, seven percent of all losses may be through seepage. Excess liquids from tailings ponds may be discharged to streams or disposed of to groundwater aquifers. Discharged waters generally are neutralized and treated to remove heavy metals and other contaminants. Water seeping from tailings ponds may contain many contaminants such as nitrates, sulfates, trace elements (for example, selenium in the Grants, New Mexico area), and organic chemicals. Ground and surface waters may become polluted. Numerous radiologic studies have illustrated that pollution of ground and surface water can occur from seepage and mill discharge. Contamination of wells by non-radioactive pollutants has resulted in contamination of livestock water in Colorado. Nitrates have polluted groundwater in New Mexico. Trees have died downgradient from a tailings pile in Colorado. Groundwater contamination with selenium and nitrates has been shown to occur near tailings ponds in the Grants Mineral Belt of New Mexico. In some areas where seepage is a problem, catchment basins or

wells have been placed downslope from the pond to intercept contaminated water and pump it back to the pond. Surface waters may be contaminated by contaminated groundwater which discharged into ponds or streams (Reed, et.al., 1976).

Liquid waste may also be injected into deep wells for disposal. The disposal zone is usually hundreds of feet below the surface. The disposal zone must be separated from aquifers by impermeable formations. It is important to properly case all injection wells. Contamination of aquifers from injected waste appears to have occurred in New Mexico. The effluents are treated to remove suspended sediment solids, to prevent plugging in the zone, and to retard growth of micro-organisms. Tailings are presently discharged into impoundments to retain solid waste, but also serve to retain liquid wastes. A 1814 million tons per day mill in Wyoming requires a tailings disposal area of about 60 hectares.

The ideal tailings pond site should be near a mill, located in an area which receives limited runoff, has downstream openings capable of being dammed, has adequate storage volume, and is underlain by an impermeable geologic formation. Natural runoff should be diverted around tailings sites (Reed, et.al., 1976).

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REGULATORY FRAMEWORK

A number of federal and state agencies administer laws and regulations concerned with mining activities and their impacts on water quality. An even greater number of agencies regulate mining activities in some general way. The Reclamation Division, Montana Department of State Lands, and the Water Quality Bureau, Montana Department of Health and Environmental Sciences, are the lead state agencies concerned with mining/water quality issues. The United States Bureau of Land Management, Geological Survey, Forest Service, and Environmental Protection Agency are the federal agencies most involved in mining/water quality issues.

FEDERAL AND STATE STATUTES AND REGULATIONS

United State Mining Law of 1872

This act, passed May 10, 1872, governs the acquisition of mining rights on large amounts of public land in the west. The principal exceptions to this act are the Mineral Leasing Act of 1920, which made certain nonmetalliferous minerals exclusively leasable and not open to acquisition by claim staking ; the Materials Act of 1947 that defined a group of salable minerals; the Multiple Mineral Use Act of 1954 that provided for multiple mineral development of the same tracts of public lands; and the Multiple Surface Use Mining Act of 1955, which withdrew common varieties from mineral entry.

The principal provisions of the 1872 mining law (1) permit staking of a claim, after discovery of a lode, vein, or placer deposit; (2) permit the exclusive right of possession of all surface within the claim for mining purposes, and (3) permit acquisition of a five-acre site for mill purposes. The claimant has the optional right to apply for a patent on his claim. If the patent is successful, the surface and minerals become private property.

The 1872 mining law recognizes the need for exploration work:

> Exploratory work is necessary, in many instances, to perfect a discovery. The general mining laws are presently interpreted as extending an express invitation to enter upon the land and explore and, upon discovery, to claim by location with the promise of full reward. The prospector who enters upon vacant public land, peacefully and in good faith, is not a trespasser, but is a licensee or a tenant at will. This right to enter is a statutory right. A mineral discovery cannot be made without the right of entry and the time to explore (U.S. Forest Service, 1977, p.7).

No permits from federal agencies are needed to explore for locatable minerals.

Although the land managing agency can require that measures be taken to protect water quality, and other surface resources, on unpatented claims, the intent of the 1872 mining law is to open all federal lands to mineral exploration and development. On unpatented claims, the Forest Service may recommend mitigation measures, but can not deny entry, for mineral exploration or development. Once a claim has gone to patent, the federal surface managing agency has almost no power to mitigate damage to surface resources.

Mineral Leasing Act of 1920

Under this act, certain minerals are considered leasable, and not locatable, and are developed through prospecting and leases. An operator can only obtain from the federal government the right to explore and mine certain minerals, but can never acquire the surface in private ownership. As since amended, this act covers oil, gas, coal, oilshale, sodium, potassium, phosphate, native asphalt, solid or semi-solid bitumen, bituminous rock, and oil-impregnated rock or sand.

The Forest Service (1977) has summarized mineral leasing procedures:

> In general, to hold a lease, the miner is required to pay an annual rental in advance, to pay a royalty to the government on all material removed and sold, and to comply with any other provisions written into the lease.

> The acquisition of mineral deposits by a lease from the Bureau of Land Management is very different from the location of a valid claim on a mineral discovery. Areas involved in leases are large compared to individual mining claims because of the nature of the occurrence of leasable minerals. Filing fees and yearly land rental fees are collected in advance, and bonds in varying amounts are required before the issuance of either a prospecting permit or a lease.
>
> In areas in which leasable mineral deposits are not known to occur, minerals can be leased by a noncompetitive procedure. In areas in which leasable mineral deposits are known to occur in marketable quantities, leases are issued to the highest bidder, either by sealed bid or at public auction. Leases issued in this manner are termed competitive leases. (p.10).

Regulations of the Secretary of the Interior for most minerals discussed in this Act are contained in 43CFR Group 3500 - Leasing of Minerals Other Than Oil and Gas. Regulation 43CFR Part 23 provides for protection of nonmineral resources during operations for discovery and development of minerals under permits and leases issued under the Act. A technical examination must be made of all proposed exploration or development areas. Based on this examination, special stipulations assuring protection of nonmineral resources and the environment, including water quality, are made part of the permit or lease. Where BLM does not administer the surface, the surface managing agency, such as the Forest Service, makes recommendations concerning these stipulations (USGS, 1977).

Materials Act of 1947

Salable minerals are petrified wood and common varieties of stone, sand, gravel, pumice, pumicite, cinders, and some clay. These materials may only be acquired by purchase from the federal land managing agency, either through competitive bid or negotiated sale. Other uses of the same land may take place if not interfering with the mining operation, and the mined land must be reclaimed.

Surface Mining Control and Reclamation Act of 1977 and Final Interim Regulations

The Surface Mining Control and Reclamation Act was signed into law on August 3, 1977. This law was passed after several years of debate and disagreement between Congress and the Presidency. The law establishes national standards for coal mining and reclamation. Of particular concern in the Act is the effect of mining on hydrologic systems.

The Act requires that the Secretary of Interior publish initial regulations applicable to all coal mining operations regulated by the states until each state has an approved regulatory program or a federal regulatory program implemented in that state. These initial regulations took effect February 3, 1978 and will stay in effect throughout the initial program phase.

Major aspects of these regulations consider (1) general performance standards for surface and underground mines governing restoration of disturbed areas to suitable post-mining use, backfilling, protection of the hydrologic system, and construction, inspection, and maintenance of dams; (2) special performance standards governing steep slope mining, prime farmlands, and mountain top removal; (3) procedures for adopting state laws where they are found to be more stringent than federal regulations; (4) regulations governing enforcement activities and inspections; and (5) financial and other assistance to eligible small coal mine operators in determining the hydrologic consequences of mining and reclamation.

Given the small scale nature of coal production in the Statewide 208 Area, a detailed analysis of these comprehensive and complex regulations is not appropriate. Several sections of the regulations have direct and indirect implications on water quality. Together with existing state statute and regulation, they constitute a stringent and complete regulation of the coal mining industry.

Operators are required to restore the hydrologic balance of the system after cessation of mining. This requirement is the most stringent of any regulation governing any type of mining in the nation. The objective of this regulation is:

> to have the permittee research and understand the hydrologic balance in the affected area as well as to understand the effect of mining on that balance so that operations are planned and conducted to minimize disturbances both on -and off-site. Since the hydrologic balance may be restored only after long periods of time, it is necessary for the permittee to project long-term trends toward restoring the balance (Office of Surface Mining, 1977 p.62649).

Specific aspects of these regulations regarding protection of the hydrologic system include:

(1) All surface drainage from disturbed areas, including reclamation areas shall be passed through a sedimentation pond. Sedimentation ponds must be maintained until the pond discharges meet specified limitations. Notable for Montana is the discharge limitation of 45 mg/l maximum allowable suspended solids and 30 mg/l average daily suspended solids for 30 consecutive days (715.17 (a)).

(2) All discharges from disturbed areas during and after reclamation, are to be adequately monitored to characterize daily and seasonal variation, normal and abnormal concentrations (715.17 (b)).

(3) Overland flow and stream channel diversions are to be designed to minimize erosion of the diversions. Permanent diversions must be self-maintaining systems requiring infrequent maintenance (715.17(c)(d)).

(4) Groundwater resources must be protected. Reclamation must ensure that the former recharge capacity of the mined area is re-established. Groundwater levels and quality must be monitored.

(5) Permanent impoundments must meet water quality standards appropriate for their final use.

Of particular emphasis to the regulations are special provisions regulating coal mining in and near alluvial valley floors, which are defined as:

> unconsolidated stream-laid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation and windblown deposits (710.5).

Mining in and near alluvial valley floors:

> Shall be planned and conducted so as to preserve the essential hydrologic functions of these alluvial valley floors throughout the mining and reclamation process. These functions shall be preserved by maintaining or re-establishing those hydrologic and biologic characteristics of the alluvial valley floor that are necessary to support the functions. The characteristics of an alluvial valley floor to be considered include, but are not limited to -
>
> (i) The longitudinal profile (gradient) cross-sectional shape, and other channel characteristics of streams;
>
> (ii) Aquifers and confining beds within the mined area which provide for storage, transmission, and regulation of natural groundwater and surface water that supply the alluvial valley floors;
>
> (iii) Quantity and quality of surface and groundwater valley floors;
>
> (iv) Depth to and seasonal fluctuations of groundwater beneath alluvial valley floors;
>
> (v) Configuration and stability of the land surface in the flood plain and adjacent low terraces in alluvial valley floors;
>
> (vi) Moisture-holding capacity of soils.
>
> (715.17 (j))

These regulations are a stringent control of mining near perennial and intermittent streams designated as alluvial valley floors. These regulations are new and it is not clear at this time how phrases such as "preserve and maintain" and "materially damage" will be interpreted whatever the case, coal strip mining near streams will be more closely controlled by the Montana Reclamation Division and the Office of Surface Mining. The clear intent of the law and regulations is to preserve existing water quality of surface and groundwater.

Federal Water Pollution Control Act Amendments of 1972 (p. 192-500)

In October, 1972 Congress amended the 1965 Federal Water Pollution Control Act. The amendments were designed to provide regulation and planning for improvement of water quality in the nation's waters. This law was designed to regulate discharges of pollutants from point sources, regulate hazardous substances and oil spills, and provide financial assistance for sewage treatment plant construction. It also provided for administration of detailed regulatory rules at the state level. In response to this law, Montana passed regulations for control of point source waste discharges and developed detailed water quality standards. Pursuant to Public Law 92-500, the NPDES (National Pollutant Discharge Elimination System) rule (40CFR 125) was passed. This rule requires permits for point source discharges of wastes and has a provision for states to become the primary administrator of the permit system. Montana has developed regulations for waste discharge permits and applied for and received authority from the EPA in 1974 to issue permits in Montana. The state program (Montana Pollutant Discharge Elimination System) is in effect for most point source discharges. The NPDES system is used in Montana for discharges from federal facilities only. There presently are no NPDES discharge permits for mining operations in Montana.

Wherever an active mine discharges water, the operator is legally required to obtain a discharge permit (usually a MPDES permit) and meet the limitations of that permit. When an operator applies for a discharge permit, limitations on the concentrations of particular pollutants are specified and are based on a number of criteria. As part of the overall strategy for elimination of pollutant discharges to the nation's waters, the EPA is establishing guidelines spelling out the maximum amount of pollutants acceptable from any particular industry. The limits required by the MPDES are based, in part, on these regulations promulgated by the EPA.

There are 21 categories that EPA considers to be the major contributors of industrial point source pollution. Of these, two relate to mining: Ore Mining and Dressing and Coal Mining. Technical studies aimed at characterizing these industries and their discharges are now being conducted by EPA. Concurrently, the technologies available for control and treatment of the characteristic pollutants and the economic impacts of the various control options are being assessed. When this process nears completion, preliminary regulations stating the maximum allowable concentrations of pollutants are published and comments are solicited. Hearings are then held and the proposed regulations are either modified or promulgated.

There are three basic levels or degrees of pollution control. The first is the application by a discharger of the best practicable control technology currently available (BPCT). A particular BPCT is determined by the EPA as described above, and is supposed to be in force in all discharge permits issued after July 1, 1977. The second degree of control is called the best available technology economically achievable (BAT) and represents a higher quality of discharged waters. Since these regulations are usually

more stringent, more time has been allowed both for determining the BAT's and for their industrial application. The deadline of July 1, 1983 was the date set by PL 92-500, but is likely to be extended one year by a bill now before Congress (Dick Montgomery, pers. comm. ; Chemical Engineering, December 5, 1977).

The third level deals with new sources of pollutant discharges. Usually in the design and construction of new plants or mining operations, a higher level of environmental control can be instituted with relatively little increase in cost. In contrast, older operations need to be modified at a greater cost , and the cost is generally not included in the original economic feasibility.

Although all the BPCT's were to be in effect by July 1, 1977, some are not yet promulgated. Because of hearing delays and a substantial amount of comment from industry and environmental groups, the BPCT's proposed for the mineral subcategories for the ore mining and dressing industry are still in the review stage. (These categories include base and precious metals, and uranium, radium and vanadium ores.)

Currently there are no BPCT's available to the Water Quality Bureau for use in determining permit limitations for these operations (Montgomery, pers. comm., 1977).

In the same industry, BPCT's have been promulgated for the four subcategories of crushed stone, construction sand and gravel, industrial sand, and phosphate rock. The first three subcategories allow total suspended solids (TSS) effluent concentrations of 45 mg/l as a maximum for any one day and an average of 25 mg/l for thirty consecutive days. The pH shall be maintained within a range of 6.0 to 9.0. In addition, in the industrial sand subcategory,

if HF flotation is employed, there is a total fluoride limitation of 0.006 mg/l maximum and 0.003 mg/l average. Phosphate rock effluent limitations are only slightly different with a TSS of 60 mg/l maximum and 30 mg/l average. The pH ranges are 6.0 to 9.0.

In the coal mining industry there are promulgated BPCT's for the two subcategories concerning mines plus coal preparation plants, and associated areas. The former requires adequate application of technologies to achieve set limits for total iron, TSS, and pH. The latter subcategory, coal preparation plants and associated areas, names a limit for total manganese in addition to iron, TSS, and pH. Both subcategories include specifications for control of runoff and sedimentation. New Source Performance Standards (NSPS) for these two categories have been proposed and include the same parameters, but with a slightly stricter iron limit.

Permits issued after July 1, 1984 (if the pending bill is passed), will require point source discharges to meet limitations achievable by the best available technology economically achievable (BAT). The EPA has released a schedule for BAT reviews for 21 industries. The ore mining and dressing and the coal mining industries will have proposed regulations published by September 30, 1978 and final regulations promulgated by March 31, 1979. The EPA has asked those states administering NPDES permits to issue those permits for a period of time short enough to incorporate the new regulations as they are now promulgated.

Montana Laws Regarding Water Pollution (Title 69, Chapter 48)

This law is the basic water pollution law of the State of Montana and is administered by the Montana Water Quality Bureau of the Department of Health and Environmental Sciences. This law defines water pollution and

general treatment standards and has an enforcement provision. It prohibits contamination or other alteration exceeding adopted standards of the physical, chemical, or biological properties of any state water. The act not only prohibits pollution, but Section 69-4806(1) states that it is unlawful to place or cause to be placed any wastes in any location where they are likely to cause pollution of any state waters. State waters are defined as: "...any body of water, irrigation system, or drainage system either surface or underground."

Montana Laws Regarding Water Pollution also require a permit for the following activities which cannot be conducted without approval from the Department of Health and Environmental Sciences:

(a) construct, modify, or operate a disposal system which discharges to any state waters; or

(b) construct or use any outlet for the discharge of sewage, industrial waste or other waste to any state water; or

(c) discharge sewage, industrial waste or other waste into any state waters.

It is clear that the law prohibits pollution but the prohibition is dependent upon promulgated water quality standards. For state surface waters such standards have been developed, however, there have been no specific standards developed for groundwater in Montana. The regulatory authority, therefore, under this law relative to groundwater pollution is somewhat limited.

Another important provision of the Montana Water Pollution Law is Section 69-4808.2(1)(c)(iii) which is called the "nondegradation statement". It states:

> The Board shall require that any state water, whose existing quality is higher than the established water standards, be maintained at that high quality unless it has affirmatively been demonstrated to the Board that a change is justifiable as a result of necessary economic social development and will not preclude present and anticipated uses of these waters.

The intent of this statement is to prevent degradation of high quality waters. In application of the law and water quality standards to effluents, this statement is of major significance. It requires that water quality of receiving waters be kept high and not be allowed to degrade to meet minimum standards.

Montana Water Quality Standards (MAC 16-2.14(10)-S13380)

The Montana Water Quality Standards have been developed pursuant to the Montana Laws Regarding Water Pollution. These standards classify all waters in the State of Montana with respect to their quality and beneficial uses. They also establish standards for parameters such as oxygen, turbidity, and temperature that must be maintained in waters of each of the various classifications. The Montana Water Quality Standards include a number of categories, but most waters in Montana are classified as being suitable for either a public water supply and propagation and growth of salmonid fishes or use as a water supply and growth and propagation of non-salmonid fishes. There are a number of other water quality categories which relate to aquatic life, irrigation, industrial water supply and public water supply.

Any waste waters from mining operations or mineral fuels developments in Montana that discharge to surface waters in Montana must meet conditions established in the Water Quality Standards. For design purposes, water quality standards must be met only for stream flows that equal or are greater than the 7-day, ten-year low flow. This flow is the minimum consecutive seven day average low flow that is equal, or exceeded once every ten years.

The Water Quality Standards establish maximum allowable changes in water quality and establish limits for pollutants which affect prescribed beneficial uses of state waters. The rule specifies minimum levels for dissolved oxygen, temperature, coliform bacteria, dissolved chemical substances, toxic materials, radioactivity, turbidity, color, odor, and other deleterious substances. In addition to specific water quality requirements, these standards also have general water quality criteria. A general criteria of importance to mining is that industrial waste is to receive, as a minimum, treatment equivalent to the best practicable control technology currently available (BPCT) as defined by EPA. In cases where BPCT is not defined by EPA, industrial waste is to receive, after maximum practicable in-plant control, a minimum of secondary treatment or equivalent. The general water quality criteria also control discharges that may cause sludge deposits, debris, scum, odors, colors, combinations of undesirable material, toxic materials, or conditions which may cause growth of undesirable aquatic life. The general water quality criteria also provide for short term exceedence of specific water quality criteria due to necessary activities such as dredging, channel or bank alterations, stream diversions or other construction activities where turbidities may exceed the criteria.

For any waste waters from mining or mineral fuels development that enter state waters, a determination must be made whether the receiving water has quality higher than established standards - meaning the Montana Water Quality Standards. If the receiving water quality exceeds these standards, then allowable changes in receiving water quality must be determined based on the nondegradation statement (Section 69-4808.2(1)(c)(iii). Current interpretation of this section by the Water Quality Bureau is that discharging

waters should cause no significant changes in chemical or biological characteristics of the receiving water.

Montana Pollutant Discharge Elimination System (MAC 16-2.14(10)-S14460)

The MPDES rule is based on the Montana Laws Regarding Water Pollution and the EPA, NPDES permit system and generally regulates all point source discharges to surface waters of Montana. Discharges from federal facilities are regulated by the federal NPDES regulation. All MPDES permits issued in Montana meet the requirements of the EPA or are more stringent than the NPDES rule.

Controls that affect mining are the imposition of best practicable control technology (BPCT) by July 1, 1977 and best available control technology (BAT) by July 1, 1984. For each discharge proposed under the MPDES rule, water quality limitations are established for the effluent. Quality of this water is based on national BPCT and BAT criteria and are also based upon receiving water quality. In cases where receiving water quality standards will be violated by waters treated to BPCT, the discharge requirements are modified to insure that no instream violations of state water quality standards will occur.

Presently, in the Statewide 208 Area, there are two MPDES permits issued to mining operations. These are U.S. Gypsum near Lewistown and the Anaconda Company operations in Butte. The Knife River Coal Mining Company, Savage, has applied for a permit.

Public Water Supply Law (Title 69, Chapter 49, R.C.M.1947)

This law deals with protection, maintenance and improvement of quality of water for public water supplies in Montana. The Board of Health and Environmental Sciences has supervision over waters used for public supply as well as the function of adopting rules and standards and issuing orders

to prevent pollution of public water supplies. This act prohibits pollution of state waters and pollution of public water supplies. This law provides some control over pollution of groundwaters since the U.S. Public Health Service and the National Safe Drinking Water Act (PL93-523) provide specific water quality requirements for water to be used for public water supplies. This law would prevent mining related pollution of groundwater that is used as a public water supply.

Refuse Disposal Areas Act (MAC 16-2.14(2)-S14100)

This rule was adopted to establish standards for solid waste disposal areas and waste management. Wastes are grouped with respect to type of material and relative hazard. Refuse disposal sites are classified with respect to the groups of wastes that they can handle. Any solid wastes generated from mines would need to be placed into a refuse disposal area. A pertinent section of this rule states: "The disposal area shall be so located as to prevent the pollution or contamination of any waters of the state." Any refuse disposal areas used for a mining operation must comply with this act thus preventing water pollution.

The Natural Streambed and Land Preservation Act of 1975

The purpose of this law is to protect natural streams, particularly streambanks and streambeds to prevent soil erosion and sedimentation. The rule is administered by the board of supervisors of a conservation district or county commissioners in areas where there is not a conservation district. Proposed actions that will affect streams such as stream crossings, bridges, culverts, must be reviewed and approved before the activity can commence. This act protects water quality since it regulates activities in streambeds, which tend to cause sedimentation problems.

Oil and Gas Regulations (MAC 36-3.18(10)-S18130.

The Oil and Gas Divison of the Department of Natural Resources and Conservation administers laws and regulations relative to the exploration, production and development of oil and gas in Montana. The Oil and Gas Division has rules that relate to water pollution problems associated with oil and gas drilling and production. Specific sections of the regulation that relate to water pollution are:

1. 36-3.18(10)-S18130 Restoration of Surface. This requires the owner of any drilled oil or gas well or seismographic shot hole to restore the land surface to its previous grade and productive capability and to take such measures to prevent hydrological effects. This regulation is designed to reduce sediment problems and prevent pollution of groundwater and surface water.

2. 36-3.18(10)-S18070 Drilling-Relating to Reserve Pits
   The operator of a drilling well shall construct his reserve pit in a manner adequate to prevent undue harm to the soil or natural water in the area. When a salt base mud system is used as the drilling medium, the reserve pit shall be sealed when necessary to prevent seepage.

3. 36-3.18(18)-S18400 Plugging and Abandonment
   Requires all seismic shot holes to be plugged and abandoned by filling with drill cuttings and bentonite. Seismic holes in artesian water deposits are to be plugged by a cement slurry. If followed, this should prevent groundwater pollution from seismic shot holes.

4. Section 228 of the Oil and Gas Rules require wells used for injection of water or gas into producing formations to be cased with "...sound casing" so as not to permit leakage and the casing cemented in such a manner as to protect oil, gas, or fresh water reservoirs.

5. Section 232 of the Oil and Gas Rules governs plugging of abandoned wells. The technique used for plugging must be described (Section 232.3); however, it does not specify a detailed method for plugging to insure there are no adverse impacts in groundwater.

6. Section 227 of the Oil and Gas Rules governs disposal of salt or brackish water produced and requires disposal in a pit where underlain by heavy clay or hardpan. Where the soil under the pit is porous or closely underlain by sand and gravel, pit disposal is prohibited. This provides protection of groundwater.

Open Cut Mining Act Title 50, Chapter 15, R.C.M. 1947

The Open Cut Mining Act regulates mining and reclamation activities associated with production of bentonite, clay, scoria, phosphate, and sand and gravel, and is administered by the Open Cut Bureau. The purpose of this act is, in part, to "preserve natural resources, and to aid in the protection of wildlife and aquatic resources" (Section 2, 50-1502). Under this law, the Department of State Lands enters, with operators, into contracts which provide for reclamation of mined areas, consistent with performance standards of the Act. All operators who mine in excess of 10,000 cubic yards of material are subject to the law (Section 7, 50-1507). Violations of this law are processed through the office of the County Attorney having jurisdiction over the mining area, or are processed by the Department of State Lands.

A few portions of the Act specifically apply to water resources:

(2) The commission may not approve any reclamation plan unless the plan provides that:

(c) where operations result in a need to prevent acid drainage or sedimentation, on or in adjoining lands or streams, there shall be provisions for the construction of earth dams or other reasonable

devices to control water drainage, provided the formation of such impoundments or devices will not interfere with other landowners' rights or contribute to water pollution.

(f) All access, haul and other support roads shall be located, constructed and maintained in such a manner as to control and minimize channeling and other erosion;

(j) Except for rock faces, bench faces and excavations used for water impoundments, each surface area of the mined premises which will be disturbed shall be revegetated when its use for extractive purposes is no longer required. Seeding and planting shall be done in a manner to achieve a permanent suitable vegetative cover for wildlife, livestock, and retardation of erosion. All seed will be drilled unless otherwise provided in the plan;

Adopted rules and regulations further clarify the Open Cut Act. These rules require that an approved reclamation contract include information on location of natural drainages and other surface waters (MAC 26-2.10(6)-S10130 (i)(b)(iv) and (c)(i)(a,d), estimated water table depth -S10130, (i)(c)(i)(g,e), and a detailed description of how sedimentation and/or water pollution will be controlled S10120, (1)(c)(ii)(a,d). Required information includes diagrams of all settling ponds and other water treatment facilities.

Certainly the strongest provision regarding water resources and mining is MAC 26-210(6) - S10140(3) which states:

> No excavations will be allowed on any river or live stream channel or floodways at locations likely to cause detrimental erosion or offer a new channel to the river or stream at times of flooding; except that such excavating may be allowed when necessary to protect and promote the health, safety, or welfare of the people.

Since adoption of this rule in November, 1974, no mining activities in streams have been permitted (Joseph Murphy, pers. comm); several applications have been rejected on this basis. All operations currently mining streambeds were approved prior to adoption of this rule. This rule effectively eliminates mining activities where physical disturbance will directly cause adverse impacts to the stream.

Hard Rock Law (Title 50, Chapter 12, R.C.M. 1947)

Mining of minerals other than oil, gas, bentonite, clay, coal, sand, gravel, phosphate, or uranium are controlled under the Hard Rock Law. This law is administered by the Hard Rock Bureau, Reclamation Division, Department of State Lands.

Sections 1 and 2 of the Act outline legislative observations and purposes concerning hard rock mining. Protection of water resources is specifically discussed in these sections:

> ...proper reclamation...is necessary to prevent undesirable surface water conditions detrimental to the general welfare, health, safety, ecology, and property rights of the citizens of the state.
> (Section 1, 50-1201)

The purposes of this Act are to provide:

> (i)... the usefulness, productivity and scenic values of all... surface waters involved in mining and mining exploration...will receive the greatest reasonable degree of protection and reclamation to beneficial use
>
> (iv) ... that the basic objective will be to establish ... water condition ... appropriate to any proposed subsequent use of the area
> (Section 2, 50-1202)

Concern is thus expressed principally for surface water protection. Other language in these sections places environmental protection in the context of the activity of mining as "a basic and essential activity making an important contribution to the economy of the state and the nation." (Section 1, 50-1201)

Reclamation is required for all exploration and mining activities regulated under exploration and operating permits. Section.9 outlines the requirements of reclamation plans for operating permits:

> (c) Provision shall be made to avoid accumulation of stagnant water in the mined area...
>
> (e) Where mining has left an open pit exceeding (2) acres of surface area, and composition of the floor and/or walls of which pit are likely to cause formation of acid, toxic, or otherwise pollutive solutions (hereinafter "objectionable effluents') on exposure to moisture, the reclamation plan must include special provisions which adequately control these effluents.

No other provisions of Section 9 concern water resources. Major concern in this section is thus expressed about acid mine drainage and other effluents produced from open pits.

An operating permit may be denied under the Hard Rock Act if:

> (A) the plan of development, mining, or reclamation conflicts with the state water ... purification standards;
>
> (B) the reclamation plan does not provide an acceptable method for accomplishment of reclamation as required by this act.
>
> (Section 14, 50-1214)

Thus, under the act, a permit could be denied if a mining or reclamation plan would result in violations of water quality standards of the Water Quality Bureau, or if the reclamation methods proposed could not result in the desired reclamation result.

Many of the rules and regulations that have been adopted pursuant to the Hard Rock Law concern water resources. Exploration roads are prohibited from being constructed up stream channels. However, minor stream alterations are permitted if the channel is not actually blocked. The Department must consult the Fish and Game Department in alterations affecting more than 100 feet of channel length (Rule 3 (a)(3). Guidelines for road crossings

of streams are also detailed (Rule 3(a)(7-8)). Drill sites may not be developed in drainageways, nor may drilling muds be discharged to streams (Rule 3 (b)(1-2). Where possible, discovery pits may not be dug in streams nor may spoil be dumped within the stream's floodway (Rule 3 (c)(1-2).

A number of subsections of Rule 5 - Reclamation Plans - concern water resources:

> D. (1) Where operations result in a need to prevent acid drainage or sedimentation, on or in adjoining lands or streams, there shall be provisions for the construction of earth dams or other reasonable devices to control water drainage, provided the formation of such impoundments or devices shall not interfere with other landowners rights or contribute to water pollution (as defined in the Montana Water Pollution Control Act as amended).
>
> (2) The plan must provide that all water, tailings or other spoils impounding structures be equipped with spillways or other devices that will protect against washouts during a one hundred (100) year flood.
>
> (3) All applicants must comply will all applicable county, state and federal laws regarding solid waste disposal. All refuse shall be disposed of in a manner that will prevent water pollution or deleterious effects upon the revegetation efforts.
>
> (4) Upon abandonment, water from the development or mining activities shall be diverted or treated in a manner designed to control siltation, erosion or other water pollution damage to streams and natural water courses.
>
> (5) All access, haul and other support roads shall be located, constructed, and maintained in such a manner as to control and minimize channeling and other erosion...
>
> (8) Provisions shall be made to avoid accumulation of stagnant water in the development area which may serve as a host or breeding ground for mosquitoes or other disease-bearing or noxious insect life...
>
> F. The plan must describe the location of the surface water diversions as well as the methods of diverting surface water around the disturbed areas. Properly protected culverts, conduits or other artificial channels may carry surface water through the disturbed areas providing such procedures prevent pollution of such waters and unnecessary erosion.

G. Requirements regarding reclamation of stream channels and stream banks must be flexible to fit circumstances of each stream site. Many stream relocations, however, will be permanent and thus will represent the reclaimed condition of stream channels and stream banks. Accordingly, reclamation plans must contain the following provisions should stream channels or banks be permanently relocated:

1. The relocated channel shall be a length equal to or greater than the original channel, unless the Board after consideration of the local circumstances shall grant a variance.

2. The relocated channel shall contain meanders, riffles, and pools similar to those in the original channel.

3. Stream banks shall be rounded to prevent slumping and sloghing and shall be revegetated in keeping with accepted agriculture or reforestation practices the first appropriate season following channel relocation.

4. Rock riprap shall be used wherever appropriate.

Small mining operations which excavate less than 36,500 tons of material each year are considered small miners and are not subject to any of the performance standards of the Hard Rock Act. A small miner must annually agree (1) not to pollute or contaminate any stream, (2) to provide protection for human and animal life, and (3) not to leave undisturbed more than five acres of ground. Failure to comply with these regulations constitutes a misdemeanor, and is subject to a fine of not less than $10 and not more than $100 (Section 19, 50-1219).

The Hard Rock Act provides the least amount of regulatory authority to the Department of State Lands of the mining laws discussed in this section. Permit denial provisions are vaguely expressed, as are specific enforcement measures.

Montana Strip and Underground Mine Reclamation Act (Title 50, Chapter 10)

This law was passed in 1973 and regulates mining of coal and uranium. After passage of the Federal Strip Mine Law in 1977, applicability of state law concerning coal strip mining became subject to federal review.

As of January, 1978, state law was still being applied throughout Montana and no determination of applicability of federal law had been made.

The relatively new Montana Strip and Underground Reclamation Act is regarded as one of the nation's most stringent strip mine laws. Sections of the act specify the nature and timing of reclamation, make operators responsible for degradation of groundwater conditions, and specify criteria whereby a permit can be denied. The Montana Reclamation Division has large discretionary powers to require submittal of substantial amounts of information concerning hydrologic systems. Although laws may be considered stringent, enforcement and administration of laws critically determine the impact of the law.

There are several sections of the act that relate to water quality. Section 2 of the act states that the policy of the state is to "protect its environmental life support systems from degradation... prevent unreasonable degradation of its natural resources."

The Department of State Lands reviews all mining and reclamation plans, including plans for water control. Surface and groundwater data is submitted as part of a mining permit application, pursuant to requirements outlined in statute rules and regulation (26-2.10(1)-S10300; S10330), and guidelines (issued 1977). The guidelines comprehensively outline data requirements for a year long pre-mining hydrologic study focusing on delineating aquifer systems, channel conditions, water quality, and water use. Except for the hydrologic data requirements for alluvial valley floor areas required in the rules pursuant to the federal Surface Mining Control and Reclamation Act of 1977 and those proposed by Hardaway, et.al. (1977), the State of

22(4) permits a surrounding landowner to sue for damages resulting from adverse impacts of mine drainage.

Rules adopted pursuant to this act require that waters impacted by mining "shall be maintained at their present high quality and such waters shall not be lowered in quality unless it is affirmatively demonstrated... that such a change is justifiable as a result of necessary economic or social development and that the change will not adversely affect the present or future uses of such waters." (26-2.0(10) - S10330(1)(a)).

This non-degradation has not been applied to any mine applications, to date.

Montana's hydrologic data collection requirements are the most comprehensive in the nation.

Section 9 of the state law permits the state to prohibit mining in certain areas. Although no land has ever been prohibited under this section solely for hydrologic considerations, several subsections do apply to hydrologic systems; including:

> (3) If the Department finds that the overburden on any part of the area of land described in the application for a prospecting, strip mining or underground mining permit is such that experience in the state with a similar type of operation upon land with similar overburden shows that substantial deposition of sediment in streambeds, subsidence landslides, or water pollution cannot feasibly be prevented, the Department shall delete that part of the land described in the application upon which the overburden exists.
>
> (4) If the Department finds that the operation will constitute a hazard to a dwelling house, public building, school, church, cemetery, commercial or institutional building, public road, stream or lake, or other public property, the Department shall delete those areas from the prospecting, strip mining or underground mining permit application before it can be approved.

Amendments to the act to include specific provisions prohibiting mining in alluvial valley floors have been repeatedly rejected by the Montana state legislature.

Section 10 (1) of the Act requires that an operator reclaim mined land and take "all measures... to eliminate damages to... streams... from soil erosion, subsidence, landslides, water pollution, and hazards dangerous to life and property. Section 10 (2) requires the operator to bury toxic materials, seal tunnels, shafts, and all related discharges, and treat all runoff and groundwater flow in order to reduce pollution of surface and groundwaters.

Section 22 (3) permits a surrounding landowner to sue an operator for damages to his/her groundwater supply. The operator must prove that mining did not adversely affect groundwater systems in a suit of this kind. Section

ADMINISTRATION OF STATUTES AND REGULATIONS

This section outlines the nature of administration of state mining and water quality laws, and federal and state oil and gas regulations.

RECLAMATION DIVISION, MONTANA DEPARTMENT OF STATE LANDS

The Reclamation Division, Department of State Lands, plays a lead role in administration of state mining and reclamation laws. The Division, comprised of 16 full-time professional staff persons, administers (1) The Montana Strip and Underground Mine Reclamation Act, (2) the Strip Mined Coal Conservation Act, (3) The Open Cut Mining Act, and (4) The Hard Rock Mining Act. Under the Strip and Underground Mine Reclamation Act, 10 strip coal mines have been permitted, each subject to permit renewal every five years. Under the same Act, 38 operations are presently permitted for coal exploration and 19 operations are presently permitted for uranium exploration. There are no permitted uranium mines in the state. Under the Open Cut Mining Act, 269 operators have valid reclamation contracts with the state for sand and gravel, scoria, bentonite, and clay mining, and one contract exists with a phosphate mining operation. The Reclamation Division administers 64 operating permits under the Hard Rock Mining Act, 46 exploration licenses, and 927 small miner exclusion statements. The mining of any commodity not specifically regulated by the Strip and Underground Mine Reclamation Act or the Open Cut Act is regulated under the Hard Rock Mining Act.

Operators are required to obtain from the Department of State Lands permits which commit them to certain mining and reclamation performance standards which vary with each law. In all cases, reclamation of mined land is required. The Reclamation Division regularly inspects mining properties

to ensure compliance with permit requirements, and ensure that all disturbed acreage is bonded and permitted. Under all laws, the Department has the power to issue notices of non-compliance, and the Attorney General has the power to fine violators.

Open Cut Bureau

The Open Cut Bureau attempts to inspect all sand and gravel operations twice each year, but does not meet this goal. Some operations are not visited annually (Joe Murphy, pers. comm.). Bentonite operations are inspected quarterly and phosphate mines, biannually. Operations are inspected for compliance with reclamation standards and permit requirements. These inspections note apparent impacts of mining activity to surface water quality. Physical disturbance of streams and evidence of mine or washing plant discharges are noted. Inspection reports are submitted to the Open Cut Bureau Chief, and, generally, all matters involving water quality and discharges are referred to the Water Quality Bureau (J. Murphy, pers. comm.). A cooperative water quality sampling program has been established with the Water Quality Bureau. Samples collected by the Open Cut Bureau have been used as the basis of a Water Quality Bureau action against Empire Sand and Gravel for discharging without a permit.

As noted above, MAC 26-2.10(6) - S10140(3) substantially discourages mining in and close to natural streambeds, thus minimizing water quality impacts of mining. Existing impacts of sand and gravel mining (Table 11) result from operations in streambeds initiated prior to adoption of S10140(3) or the Open Cut Law itself, or are operations begun without permit review. A few water quality problems have developed with Montana Highway Department gravel pits. Under Reclamation Contract 00149 between the Highway Department and the Department of State Lands, all gravel pits opened by Highway Department

contractors must be reviewed and approved by the Reclamation Division, prior to excavation. On occassion, this process has not been followed:

The Highway Department excavated a gravel pit near Warm Springs, Deer Lodge County, (5N9W7), in 1977, without notifying or obtaining approval from the Reclamation Division. An inspection of the pit in August, 1977, "revealed that an aquifer, which appears to be bearing iron oxides, has been intercepted in the southeast corner of the pit ..." The pit was to be reclaimed to waterfowl habitat. However, miscalculation regarding the quality and quantity of material available may render the plan inoperative." (written comm. DSL to Highway Department, August 22, 1977). The State Lands Department notes that iron concentrations in the pit may be toxic to fish. No adequate reclamation plan has yet been filed for this operation; and there does not appear to be sufficient material available to backfill the pit (J. Murphy, pers. comm.).

Zook Brothers Construction Company, Great Falls, working on contract to the Highway Department excavated gravel and sand in summer, 1977, from a gravel bar in the Middle Fork, Flathead River, causing sedimentation problems. The Middle Fork is a designated Wild and Scenic River. Sedimentation problems from this mining have been recognized by the Flathead National Forest and the Department of Fish and Game. The Flathead County Attorney is presently processing a complaint on this action.

In 1976, the Highway Department excavated a gravel pit without DSL notification or approval near Deer Lodge along the Clark Fork (6N9W16BC). This pit is expected to be captured by the Clark Fork during a future flood flow (J. Murphy, pers. comm.).

In 1971 or 1972, the Highway Deparment excavated a gravel pit near Garrison along the Clark Fork (9N10W15A). This pit has now been captured by the stream, and erosion of an old dump is now occuring at the downstream end of the pit (J. Murphy, pers. comm.).

Some enforcement problems have occurred where county attorneys have declined to prosecute operators for excavating without a permit. Under the Open Cut Act, violations of this type are processed through the county attorney's office. Bozeman Sand and Gravel has been cited three times, the last being in 1975, for excavating without a permit. No action has been taken by the Gallatin county attorney. In 1976, the city of Broadus excavated a gravel pit in an active flood channel of the Powder River with no notification or approval by DSL. The Powder River county attorney has taken no action in a complaint filed by DSL.

Hard Rock Bureau

All mines with operating permits are inspected by the Hard Rock Bureau quarterly. Small miners are visited once a year. During these inspections, compliance with the various provisions of the Hard Rock Act are noted and inspection reports filed.

Water quality is of concern at many hard rock operations. Regular mine inspections have noted discharges to streams, failures of tailings dams, erosion of disturbed areas, and recommendations of channel relocations. In many, but not all, cases, the Water Quality Bureau has been involved in the inspection of water quality problems and has worked cooperatively with the Hard Rock Bureau. The Bureau also works with the Forest Service on some mine problems. Generally, however the Hard Rock Bureau has less interagency communication than other bureaus of the Reclamation Division.

Some hard rock mine water quality problems are long term and unresolved to date, for example, Pacific Silica (6N5W16) and Bullock Brothers Crystal Mine (7N5W20). Review of Department memoranda leaves many questions regarding resolution of water quality problems identified during inspections. Discussions with Hard Rock and Water Quality Bureau staffs indicates that an open communications link concerning water quality problems at hard rock mines does not exist.

Many specific water quality problems result from small miner activities. Presently, the Hard Rock Bureau works with small miners in eliminating or abating water pollution problems, but has not adequately enforced water pollution sections of the Hard Rock Act.

Section 20 (50-1220(1)) of the Hard Rock Mining Act states that a small miner "shall not pollute or contaminate any stream." Section 21(50-1221) states that "all information obtained from small miners is confidential except as to the name of the applicant and the county of proposed operation." This same section also states that any information obtained by the Department of State Lands (DSL) "is not confidential when a violation of the act or rules has been determined by the Department." The DSL does not make determinations of stream pollution (Dave Woodgerd, DSL attorney, pers. comm.). DSL recognizes the Water Quality Bureau as lead agency on water pollution matters since it has the proper expertise to evaluate pollution of streams (Dave Woodgerd, pers. comm.). The DSL does not release any information about potential water pollution problems that it observes in its inspections of mines because it feels that under Section 21 of the Hard Rock Act, this information is confidential. Since DSL will make no determinations as to water pollution because it does not have the expertise to make such decisions, and since the Department will not release any information to the Water

Quality Bureau about potential water pollution problems, the Department of State Lands enforcement of water pollution control provisions (Section 20) has been and is, inadequate.

There are presently over 900 small miner exclusion statements on file with the Department of State Lands. In the history of administration of the Hard Rock Act, no violation has ever been issued to any small miner for violation of subsection 1 of Section 20, the Hard Rock Act.

Coal and Uranium Bureau

The Coal and Uranium Bureau has 7½ full-time professional staff members, including a hydrologist. A second hydrologist will be added to the staff. This staff reviews the nine operating coal mines in the state, as well as coal and uranium exploration activities. Generally, the staff concentrates on a few operations, and rotates its review process, depending on permit review deadlines.

Inspections of coal strip mines have resulted in the issuance of notices of non-compliances relating to uncontrolled erosion of permitted areas resulting in sedimentation in unpermitted ephemeral channels at the Knife River and Peabody Mines. No non-compliances have ever been issued regarding discharges to running streams or lakes. Discharges from the Decker and Westmoreland Mines are regularly monitored.

The Coal and Uranium Bureau has worked with the Water Quality Bureau on water resource problems associated with nearly every coal mine in the state. The Water Quality Bureau reviews settling pond and treatment facilities, and is regularly contacted concerning mine discharge questions. The Coal and Uranium Bureau generally works with other agencies on reclamation erosion and sedimentation, and channel stabilization problems. The Coal and Uranium Bureau works closely with the Office of Energy Activities,

EPA, Denver and thus also receives imput from this source on water quality issues. Generally, the Coal and Uranium Bureau has close working contact with several other agencies involved in water quality, and thus receives independent review of many water quality problems. It is unclear at this time how the Reclamation Division and the Federal Office of Surface Mining will work together.

Water Quality Bureau

The Water Quality Bureau (WQB) has 21 professionals in its Helena office, five professionals in its Billings office, and two professionals in its Kalispell office. Laws and rules that the WQB administers which directly relate to mining are the Montana Laws Regarding Water Pollution, Water Quality Standards, and Montana Pollutant Discharge Elimination System. In the Helena office, four professionals are assigned to the permit, enforcement, and complaint section, which handles MPDES permits and water quality violations. Other responsibilities of the WQB include construction grants for waste water plants, certification and training of operators, education, industrial and municipal permits, non-point source problems, 208 management planning, water quality surveillance and monitoring, and technical investigations. The Water Quality Bureau receives legal support from the legal division of the Montana Department of Health and Environmental Sciences.

There are approximately 250 MPDES Waste Discharge Permits in Montana including four that relate to mining activities in the Statewide 208 Area. According to the WQB (J. Brown pers. comm.) compliance monitoring of major municipal dischargers is done once per year, and major industrial dischargers, twice per year. Compliance monitoring of minor discharges is conducted as time and staff permit.

The Water Quality Bureau generally receives complaints of environmental problems related to water quality from other agencies, organizations, or individuals that have discovered water quality problems. In general, the WQB acts on each complaint. Due to staff and funding limitations, the WQB does not have an active program of sampling Montana's waters to determine

if water quality standards are being violated. There is some emphasis on obtaining funding from other federal and state agencies to investigate specific water quality problems and impacts such as saline seep, mining, and silviculture, which might lead to water quality problems. Many of the WQB activities are designed to avoid future problems for example, by ensuring the proper construction of waste treatment facilities, certifying waste water operators, and assistance to those dischargers developing waste discharge facilities.

Enforcement activities of the WQB are limited by current administration of the small miner provision of the Hard Rock Act (J. Rassmussen, pers. comm.) Other enforcement problems relate to the legal status of old mines relative to new owners. Unresolved questions remain as to how much of an old mine a new owner is responsible for.

In the past five years, the Water Quality Bureau enforcement program has rapidly developed and has greatly improved. Procedures used to achieve compliance with water quality standards are enforcement letters, compliance orders, and complaints. These give the Water Quality Bureau the ability to correct problems, and if necessary, to levy fines for violation of water quality laws and rules. The legal action that has been taken by the Water Quality Bureau in the past two years are summarized in Table 16. The list contains at least 90 percent of the legal actions that have ever been taken on mining problems in Montana. As shown by this list, a dominant problem is unauthorized discharges by sand and gravel operations, and unauthorized discharges from reactivating mills or mines. Nearly all the mining violations have occurred in western, and particularly, in southwestern Montana.

Table 16.

Statewide 208 Area

Regulatory Activities of the Water Quality Bureau
for Mining Related Water Quality Problems

LOCATION	ACTIVITY	COMPLAINT RECEIVED	PROBLEM	ACTION
Trapper Cr. Beaverhead Co.	mineral processing	9/76	tailing discharge to Trapper Cr.	tailing cleaned up and required change in system to prevent future problems
Stone Cr.	talc processing	4/28/76	talc in stream	applied for permit
Boulder R. Jefferson Co.	silica mine	8/02/76	turbid water	compliance order issued; being corrected
Prickly Pear Cr. Jefferson Co.	cement manufacture	7/23/76	turbid water	complaint filed; fine paid
Hughes Cr. Ravalli Co.	mining co.	9/10/76	tailing in creek	compliance order corrected tailings discharge
Indian Cr. Sheridan Co.	mining co.	10/76	unpermitted ~~plant~~ mine discharge into creek	enforcement letter; permit being drafted by WQB
Sheridan Co.	mining co.	11/04/76	mill discharge to creek	discharge eliminated
Silver Cr. Lewis and Clark	mill operation	12/20/76	cyanide discharge	compliance order issued; discharge stopped
Sun River Vaughn, MT.	sand and gravel pit	2/03/77	reported discharge to stream	enforcement letter; no further discharges
Snowshoe Cr.	old tailings area	3/31/77	zinc discharge to creek from tailings	under investigation
Alder Cr. Madison Co.	placer mining	4/22/77	turbidity in stream	no action

LOCATION	ACTIVITY	COMPLAINT RECEIVED	PROBLEM	ACTION
Fool Hen Cr. Lewis and Clark	mine tailings	4/25/77	mine discharge	abandoned mine; no action
Douglas Cr. Phillipsburg Co.	mine discharge	6/77	unpermitted mine discharge	abandoned mine; enforcement letter
Cataract Cr. Jefferson Co.	tailings and mine discharge	7/07/77	unpermitted mine discharge	compliance order issued; eliminatio of discharge required
Alder Gulch Cr. Madison Co.	placer mine	7/06/77	turbidity in creek	compliance order; discharge eliminated; operation stopped
irrigation ditch	mine discharge	9/02/77	unpermitted discharge	no action; discharge not confirmed
Jefferson Co.	mine tailings discharge	10/03/77	unpermitted discharge	under investigatio
Stanley Cr.	metals mine exploration	9/27/77	drilling mud in creek	enforcement letter discharge stopped
E. Gallatin Gallatin Co.	sand and gravel	10/28/77	turbidity in stream	compliance order issued to eliminate discharge
Sun River Cascade Co.	sand and gravel	12/30/76	discharge without permit	compliant filed; fine assessed; discharge eliminate
Prickly Pear Cr. Lewis and Clark	sand and gravel	12/05/75	discharge without permit	complaint filed; in process
Silver Bow Cr. Silver Bow Co.	copper mine - cencentration	8/25/77	pH too high in discharge	enforcement letter; problem corrected
Silver Bow Cr. Silver Bow Co.	copper mine - concentration	2/14/77	seepage from waste pond	enforcement letter; seepage eliminated

Source: J. Rassmussen, Enforcement Office, Water Quality Bureau pers. comm., Feb., 1978

Water Quality Bureau personnel estimate that approximately 75 percent of the mining related water quality problems are referred to them by the Department of State Lands, primarily from the Open Cut and Hard Rock Bureaus; about 20 percent of the problems come from the Fish and Game Department or the U.S. Forest Service, and a few from private individuals (Jim Rassmussen, pers. comm.). There have been several complaints related to brine pollution from oil activities in Montana primarily in the northeast corner of the state where brines are thought to have polluted groundwater. All complaints concerning oil activities have been received from private individuals or organizations and none have been received from the Oil and Gas Commission or the USGS (Jim Rassmussen, Pers. comm.).

The Water Quality Bureau acts on all complaints received. Actions generally involve a field investigation of the problem, discussion with mine owners or operators, and application of an administrative or legal remedy to the problem. Water Quality Bureau enforcement personnel feel that there has been a great improvement in enforcement in Montana in the last few years, but that enforcement is still inhibited by inadequate staff, low salaries, inadequate funding, and particularly, by lack of field investigation personnel (Jim Brown, pers. comm. 1978).

Oil and Gas Regulation: Montana Oil and Gas Commission and U.S. Geological Survey, Conservation District

The Montana Oil and Gas Commission is responsible for administration of state rules relative to oil and gas development in Montana. Commission regulations are not explicit concerning the avoidance of water quality problems in road and pad construction, exploration drilling, and plugging of holes. Rules concerning well plugging and abandonment are permissive in nature, not mandatory, and plugging procedures are usually determined cooperatively between the driller and the Commission. Most operations, however, require the concurrence of the Commission, and there is some spot checking of drilling operations to ensure compliance with rules and ensure that no adverse problems develop.

The Oil and Gas Commission was able to identify only a few specific problems related to drilling and production activities. A number of problems related to oil processing, however, were cited.

Another agency with substantial regulatory responsibility in Montana is the U.S. Geological Survey, Conservation Division, which administers federal oil and gas operating regulations related to oil and gas development on all federal and federally administered lands in Montana. Supervision by the USGS begins after the land management agency, for example, BLM or Forest Service, determines where gas and oil activities can occur. Responsibility for drilling and development supervision lies with the Conservation Division.

Personnel of the USGS identified only a few specific problems associated with oil and gas development. The Division emphasizes problem prevention. Proposed drill sites are examined prior to development. Proposed drilling sites are seldom changed, however, and less than one percent of proposed sites are denied. The Conservation Division cited only two denials in the past four years and nearby alternate sites were found in both cases (Lee Pauli, pers. comm.).

The professional staff of the USGS consists of four petroleum engineers, two environmental scientists, and three technicians. The environmental scientists generally examine well sites before they are drilled and after operations commence. Technicians examine the well sites during the operation (Lee Pauli, pers. comm.). It is estimated that approximately 150 sites each year are drilled for oil and gas.

One important consideration in protection of water quality is that many regulations enforced by the Conservation Division are not specific and have few specific mandatory requirements. There are a few penalty provisions in the regulations. There is little contact between the Conservation Division and the Water Quality Bureau, and the Conservation Division is unsure who the responsible agency in the State of Montana is for administration of water pollution control laws. Another fact that emerged from discussions with the USGS is that they are understaffed and do not have the ability to examine sites in detail to ensure that rules are being enforced. Typically they must "take the word of the cement company" that the holes are properly plugged after abandonment (Lee Pauli, pers. comm.).

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MANAGEMENT CONTROL STRATEGY

Control of mining-related water quality impacts needs to focus both on correcting existing problems and on anticipating and preventing future problems. There are many existing water quality impacts from mining,and a recognition of these problems is important. Commonly, the most significant problems are the most costly to correct. Society is probably not willing to pay the price (tens of millions of dollars) necessary to return,for instance, Belt Creek to its pre-mining condition. Smaller problems may be correctable on a more reasonable cost effectiveness basis. Many of these small problems are identified in this report. Small problems, however, are often the most difficult to identify, and there is no comprehensive source for this information. Detailed field investigations are thus necessary.

The difficulty of correcting major mining problems and identifying minor problems makes it imperative that the Water Quality Bureau adopt a preventative strategy for future mining problems. It, typically, is much easier to correct a problem before it impacts surrounding waters, while the operator is still on site, and is far less costly, economically and environmentally, than correcting an abandoned mine problem.

Components of a strategy to control future mining problems include: 1. predicting the types, location, and extent of mining projected for the future, 2. monitoring exploration activity and baseline hydrologic conditions in likely development areas, 3. assisting mining companies in developing programs to avoid problems during exploration and development, and 4. comprehensively reviewing mining and reclamation plans to ensure that point and non-point pollution is eliminated. In order to adopt this program, the Water Quality Bureau should work closely with

the Reclamation Division, Geological Survey, Oil and Gas Commission, Forest Service, Bureau of Mines and Geology, and mining associations and others related to mining and mineral fuels to develop a sound cooperative working relationship.

Specific recommendations in this report constitute an overall strategy to manage mining-related water quality problems.

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